SURGERY
GYNECOLOGY AND OBSTETRICS
An International Magazine, Published Monthly

VOLUME 68 FEBRUARY 1, 1939 NUMBER 2

ASEPTIC NECROSIS OF BONE

I. Infarction of Bones in Caisson Disease Resulting in Encapsulated and Calcified Areas in Diaphyses and in Arthritis Deformans

S. C. KAHLSTROM, M.D., Bath, New York, and C. C. BURTON, M.D., F.A.C.S., Dayton, Ohio
D. B. PHEMISTER, M.D., F.A.C.S., Chicago, Illinois

CAISSON disease is the result of injury to tissues by nitrogen bubbles liberated when the body, which in compressed air has absorbed an excess of nitrogen, is too rapidly removed from the decompression chamber. This explanation was first offered by Paul Bert in 1871 and it has been substantiated by the studies of Heller, Mager and Schrotter, Boycott, Damant and Haldane, Bornstein (6, 7), and others.

The amount of nitrogen absorbed varies with the duration and height of the pressure and with the different types of tissues. According to Bornstein, nitrogen saturation for a given pressure is not complete for 7 to 10 hours. Boycott, Damant, and Haldane estimated that there is practically complete saturation for man at high pressures in 5 hours. Bohr and Henriques showed that 100 cubic centimeters of shed blood absorbs at body temperature and one atmosphere pressure 1.2 cubic centimeters of nitrogen and at 4 atmospheres 4.8 cubic centimeters. As to the different types of tissues, fat has been found to absorb the largest amount of nitrogen. Vernon reported that at body temperature and atmospheric pressure, fats (lard, olive oil, cod liver oil) dissolve more than five times as much nitrogen as an equal volume of water or blood plasma. He attributed the special tendency of the fat or lipoid containing tissues, such as subcutaneous tissues, spinal cord and nerves, to suffer injury in caisson disease to this great solubility. Attention was called to the large amount of fat in the marrow of some bones but no mention was made of known lesions of the bones in caisson disease.

It has also been found (Bornstein) that the less active the circulation of a tissue the more slowly it absorbs nitrogen and in turn, the more slowly is the gas removed from it by the circulation when the increased pressure is reduced; consequently the greater the likelihood of gas bubble formation in it. The nitrogen has been found to damage the tissues most extensively by producing embolism but it also damages by the pressure of gas bubbles extravascularly.

Dr. Kahlstrom and Dr. Burton, from the U. S. Veterans Administration.
Dr. Phemister, from the Department of Surgery of The University of Chicago.
Published with the permission of the Medical Director of the Veterans Administration who assumes no responsibility for the opinions expressed or the conclusions drawn by the authors.

631

Acute symptoms of caisson disease appearing a few minutes to hours after too rapid exit from the chamber are referable most frequently to the spinal cord, internal ears, brain, subcutaneous tissues, and the limbs. The commonest complaints are severe pains, especially in the abdomen ("bends") and in the extremities, ringing in the ears with or without impairment of hearing, hemorrhages in the skin and mucous membranes, bluish mottled discoloration and induration of the skin and subcutaneous tissues, and in some cases, paralysis in the extremities. Severe cases may cause cerebral or pulmonary embolic symptoms and death may be an early result. Prompt recompression usually ameliorates and sometimes completely relieves the symptoms. Chronic lesions sometimes result from caisson disease, the most important being impairment of hearing, paralysis from spinal cord damage, and disturbances of the bones and joints.

Pains in the extremities in the early stages have often been referred to as in the joints, particularly the hips, less often the knees, ankles, and shoulders. In most instances, they clear up but in some cases symptoms and signs similar to those of chronic deforming arthritis have continued. Chronic pains in the course of the bones have also been present in some cases.

Bornstein and Plate and independently Bassoe were the first to describe joint lesions in caisson disease. Bornstein and Plate in 1911 reported 3 cases in which symptoms and signs were present resembling chronic arthritis. A shoulder was involved in one case, one hip in another, and both hips in the third case. Roentgenograms of the hips revealed mottled changes in density in the head of the bone with flattening of its articular surface, irregularity and slight narrowing of cartilage space, and marginal lipping. The findings were considered those of arthritis deformans but they thought that the lesion was due to nitrogen bubbles in the bone bordering on the joint and not to nitrogen in the joint. No more detailed definition of the lesion was attempted.

In his report on the late manifestations of compressed air diseases Bassoe described deforming changes in the joints and also changes in the bones away from the joints. There were 2 cases of involvement of the hip, 1 of 11 and the other of 13 years' standing, in which roentgenologically the head showed mottling and flattening and there was narrowing of cartilage space and lipping which led to a diagnosis of arthritis deformans. In another case there was a similar change in the head of the humerus and lipping of the glenoid margins.

Twynam, in 1888, reported the case of a man who had severe symptoms of caisson disease with pain and swelling above the right knee and 2 months from the onset abscess formation which was drained. Later on there was another painful swelling about the right trochanter which was drained and sinuses persisted for 2 years, at which time amputation was performed through the lower third of the femur. The entire shaft of the femur was found to be necrotic and there was involucrum one-third of an inch thick surrounding it. This appears to have been a case of massive necrosis of the shaft of the femur with secondary infection which resulted in a picture resembling closely that of pyogenic osteomyelitis.

Chronic changes in the cancellous bone away from the joints was noted roentgenologically by Bassoe three times, once in the upper and once in the lower diaphysis of the tibia and once in the lower epiphysis of the fibula. There were mottled areas of absorption and irregular lines of new bone formation. No definite interpretation was made of these bone changes, and there were no reproductions of the roentgenograms in the article. Fortunately, the roentgenograms of the tibial lesions have been preserved and with Dr. Bassoe's permission they were compared with roentgenograms showing tibial lesions in some of the cases here reported and found to be quite similar.

A number of reports have since been made of the joint changes in caisson disease. Plate in 1928 reported a case and considered the change to be analogous to arthritis deformans. Burkhardt classified caisson lesions of the joints under the category of arthritis deformans but considered the primary lesion most likely in the adjacent bone. Christ in 1934 published a very comprehensive review

of the literature with a report of 4 cases involving the hip joint in one of which the lesion was bilateral. Symptoms were of relatively short duration, ranging from 4 to 18 months. All had worked from 3 to 4 years in compressed air. In all 4 cases the head of the femur roentgenologically showed scattered areas of reduced density, mixed usually with blurred areas of normal to slightly increased density. There was a variable amount of irregularity of the shadow of the articular cortex and slight flattening of the weight bearing surface of the head in each case. The cartilage space was little narrowed and the acetabulum little changed. Slight marginal lipping of the head was present in 3 cases. Christ concluded that nitrogen gas embolism had occurred in the vessels of the head of the femur producing subchondral necrosis of bone. This was followed by spotted absorption of the necrotic bone with irregularity and sinking in of the articular surface. He mentioned gas bubble formation in the bone but considered it unlikely despite the presence of fat in the medullary canal and the sluggish circulation of the bone marrow.

No case has been reported in the literature in which pathological examination has been made of the bone and joint changes except the grossly examined infected bone which was reported by Twynam.

CASE REPORTS

Four cases of caisson disease with extensive changes in the skeleton have been studied clinically and roentgenologically. One case came to autopsy and in another a biopsy was performed on the involved head of the femur. Extensive lesions were revealed in diaphyses and in epiphyses of certain bones with changes in the joints, all of which appeared to be the result of massive aseptic necrosis of bone secondary to interruption of its blood supply by the liberated nitrogen gas.

CASE 1. Necrosis of epiphyses with secondary deforming arthritis and massive necrosis of shafts of long bones in caisson disease of 35 years' standing.

A 61 year old white male has been a member of the Veterans' Administration Facility, Bath, New York, intermittently since 1930. His chief complaint is pain and limitation of motion in the hips and to a less extent in the left shoulder and knees. He has also had varicose veins of both legs for many years with swelling, pruritus, and repeated attacks of thrombophlebitis.

Fig. 1. Case 1. Deforming arthritis of both hips and loose body, *a*.

The complaint referable to the joints dates back to an attack of caisson disease in about 1901 when he worked on the construction of the Cleveland Water Works tunnel. He was incapacitated for 6 or 7 days due to the severe pains experienced in the arms, hips, and legs. He never completely recovered and by 1907 he limped, favoring the left leg. By 1917 he had adopted the use of a cane and by 1930 his hips were so troublesome that he gave up his trade, that of a gunsmith. He has had a chronic cough most of the time for 5 years and during the past 2 months it has been severe and productive. Roentgenograms of the chest taken at intervals since 1933 show no lung change until 1936, when an infiltrative process was revealed extending into the right upper lobe from the right hilum.

Past history reveals no joint disturbance whatsoever before the occurrence of the caisson disease. There is no history of other illnesses of consequence.

Physical examination. Patient is an obese elderly man in fair general condition. He walks with a marked limp favoring the left leg and with the aid of a cane. Regional examination is essentially negative aside from the chest, left shoulder, spine, and lower extremities. There is dullness and impaired breath sounds are present over the right upper lobe, especially posteriorly. There is a rather conspicuous atrophy of the muscles about the left shoulder. Elevation of the left arm is limited to about 90 degrees. There is a definite scoliosis of the dorsolumbar region with convexity to the right. There is practically no abduction of either hip and considerable limitation of both rotation and flexion of both hips. Motion in the knees and ankles is practically normal. There are varicosities and scars from old varicose vein operations in both legs. The lower left leg is slightly swollen. Reflexes are present in both upper and lower extremities.

Laboratory findings. Laboratory examinations revea inegative blood Wassermann and Kahn tests; blood calcium and phosphorus, normal; normal white count; red blood cells, 4,000,000. Urine shows albumin with occasional hyaline and granular casts.

Roentgenograms were made of the entire skeleton. The hips showed very extensive changes most marked on the left side (Fig. 1). There is marked flattening of the femoral heads with a narrowing of

Fig. 2. Case 1. Central necrotic area in shaft of left femur with calcified and ossified zone of demarcation.

the cartilage spaces and marginal lipping, especially on the right side. There are scattered areas of reduced density in the subarticular portions of the femoral heads and acetabula, interspersed with areas of increased density.

Anteroposterior and lateral roentgenograms of the lower three-fourths of the left femur reveal an oblong area of altered density in the medullary region beginning 2½ centimeters above the condyles and extending upward for a distance of 18 centimeters (Fig. 2). It occupies almost the entire width of the medullary cavity below and tapers off irregularly above. It is surrounded by a narrow irregular zone of increased density most marked along the mesial and posterior sides. The density of the interior is mottled, being slightly increased in most of its extent as compared with that of the normally appearing cancellous bone below the lesion. The shadow of the cortex surrounding this area shows slightly longitudinal streaking, but the shaft is not increased in thickness.

A roentgenogram of the right femur shows a similar area in the same region (Fig. 3). The area is 19 centimeters long and is 4.5 centimeters broad at the lower end in the anteroposterior view. There is a narrow dense zone about the periphery in almost its entire extent. Just beyond its upper limit there is a separate island 1 centimeter in diameter, with a dense zone about its periphery. There is a dense streak within, 3 centimeters above the lower end in the anteroposterior view and another crossing the involved area transversely 10 centimeters above the lower end seen in the lateral view. The cortex surrounding the area is longitudinally streaked in places and appears slightly irregular in outline in the anteroposterior view. There is a dense island in the external condyle of femur. These areas in the femurs are interpreted to represent masses of old aseptic dead bone that have had a calcareous capsule laid down about them.

A roentgenogram of the left shoulder joint and humerus shows extensive changes, those in humerus tapering downward for a distance of 20 centimeters (Fig. 4). There is a slight flattening of the articular cortex and slight bony overgrowth at the lower margin of the head of the humerus. There is a dense shadow resembling an osteophyte or loose body at the upper margin of the glenoid and another mesial to the surgical neck of the humerus just below the glenoid margin. There is a mottled increased density in the mesial portion of the upper end of the shaft extending to the anatomical neck and into the upper portion of greater tuberosity. There is an oval area 7 centimeters long extending downward in the shaft of the humerus with a zone of increased density about its periphery, most marked at the upper and lower ends. The interior of this area is somewhat mottled in appearance and there is a faint network of increased density extending down the medullary canal from this.

A roentgenogram of the left tibia shows irregular lines of sharply increased density extending slightly obliquely across the shaft in the medullary region 12 centimeters below the knee joint (Fig. 5). There is also an island of slightly increased density in the mesial portion of the upper end of the shaft about 1.5 centimeters in diameter though hazy in outline. There is a narrow transverse line partly traversing the medullary region about 7 centimeters above the lower end of the shaft of the tibia, which has the appearance of an old growth arrest line. Roentgenograms of the lower thoracic and lumbar spine reveal the end stage changes of moderate adolescent scoliosis without any evidence of lesions in the bones of the type seen in the humerus, femurs, and tibia.

Roentgenograms of the chest, including the cervical spine, reveal no changes in the clavicles and none in the spine and ribs except those resultant from scoliosis. There is a large area of increased density in the region of the right upper lobe which is sharply outlined.

The lung condition was diagnosed as bronchiogenic carcinoma. The patient's chest symptoms fluctuated during the next few months but the cough continued. He gradually lost strength and developed edema of the dependent portions with increased non-

Fig. 3.

Fig. 3. Case 1. Central necrotic area in the shaft of the left femur. The calcified and ossified zone of demarcation and the calcified necrotic island in the external condyle, *x*, are clearly shown.

Fig. 4.

Fig. 4. Case 1. Loose bodies in shoulder joint and walled off necrotic area in upper half of humerus.

Fig. 5.

Fig. 5. Case 1. Sclerosed patches in upper diaphysis of tibia.

protein nitrogen of the blood and died December 5, 1937.

Autopsy. At autopsy the following anatomical diagnoses were made: bronchiogenic carcinoma of the right lung with extension into the superior vena cava; chronic nephritis; cardiac hypertrophy and dilatation; arteriosclerosis, most marked in aorta; duodenal ulcer (five small ulcers); cholelithiasis; cicatrices and pigmentation of legs; scoliosis, ancient; infarcts, ancient, massive, in shafts of both femurs and left humerus and minimal in shaft of left tibia; arthritis, chronic, deforming, of hips and left shoulder secondary to necrosis of heads of femurs and humerus; osteocartilaginous loose bodies in left shoulder and right hip.

The entire right upper lung lobe was involved in carcinoma originating in the bronchus. It penetrated and largely blocked the superior vena cava near its termination. No distinct tumor metastases were found. The heart was moderately hypertrophied but the coronary vessels were patent and smooth throughout. The heart valves appeared normal. There were no signs of infarcts, old or recent, in heart muscle, kidneys, spleen, or brain.

Skeletal structures. There was marked right lumbar scoliosis with conspicuous articular proliferation. The trunk bones otherwise showed no outward changes. The right sixth rib was removed and sectioned. No abnormalities were seen. The left scapula and humerus, both innominate bones, both femurs, and the left tibia were removed. When the left shoulder was opened marked villous proliferation of the synovial membrane and thickening of the capsule were noted. It contained seven osteocartilaginous loose bodies ranging from 1 to 2 centimeters in diameter, some of which were flattened and nodular. The articular cartilage of the glenoid was somewhat frayed but there was no marginal lipping or change in the underlying bone. Roentgenograms showed the same changes in the bones as were present at the examination on admission.

Left humerus. The head of the humerus was flattened and its articular surface rough with marked proliferation of the surrounding borders. The articular cartilage was markedly thinned and in places entirely wanting. Section of the humerus (Fig. 6) showed 2 cystic areas in the head containing necrotic and gelatinous material. The proximal half of the shaft presented an irregular circumscribed area of necrosis of the medullary portion. It measured 17.5 centimeters in length and varied in width from 20 millimeters in the proximal portion to 4 millimeters in the distal portion. It was surrounded

Fig. 6. Case 1. Central necrotic area in upper half of diaphysis of left humerus. Deforming arthritis in humeral head and 7 osteocartilaginous loose bodies in shoulder joint.

by a dense wall which varied greatly in thickness at different levels, being thickest at the upper and lower limits. The center contained brownish to grayish friable débris and there were calcareous bridges crossing its middle portion. The cortex of the upper half of the shaft was approximately normal in appearance, but there was an irregular zone of cancellous bone of increased density between it and the wall of the central necrotic area. The lower half of the humerus and the elbow joint were normal.

The capsule of the left hip was somewhat thickened and the synovia showed moderate villous arthritis with lymphocytic infiltration. The femoral head was markedly flattened, devoid of articular cartilage and surrounded by marginal osteophytes. There was destruction of articular cartilage of the glenoid which was changed in shape to fit the altered head, and there was a long osteophyte extending outward from the superior margin of the acetabulum. There was also a marginal osteophyte in the region of the cotyloid notch. An osteocartilaginous body was attached by a pedicle to the inferior portion of the capsule.

Fig. 7. Case 1. Section of femurs showing remnants of infarcts in lower half and resolved but deformed femoral heads. Partly calcified, incompletely resolved area of necrosis at *a*.

Coronal sections were made of the left femur (Fig. 7) and left innominate bone passing through the hip joint. The acetabular portion of the innominate bone showed marked sclerosis with a few scattered cystic areas in its mesial portion. The bone away from the acetabular region was normal in appearance.

The shaft of the left femur was normal to external appearance. The cut surface of the flattened head showed it to consist of irregular dense bone surrounding cystic areas beneath the articular surface and extending into the proximal portion of the neck. Osteophytosis was most marked at the lower margin. The remaining portion of the neck and upper half of shaft of the femur appeared normal. The distal half of the shaft contained an incapsulated area of necrotic grayish friable débris measuring 15 centimeters in length and varying in width approximately from 4 millimeters at its upper end to 25 millimeters at its lower end, which extended to within 2 centimeters of the epiphysis. It was surrounded by a dark hard zone varying from ⅓ to ½ centimeter in thickness. There were areas of cancellous bone and calcareous deposit within the necrotic débris. The cortex surrounding the necrotic area was approximately normal in appearance but there was sclerosed cancellous bone about the dense capsule. The lower epiphysis, articular surface of the femur, and the lining of the knee were normal in appearance.

The right hip. The capsule of the right hip was also thickened and there were many villi springing

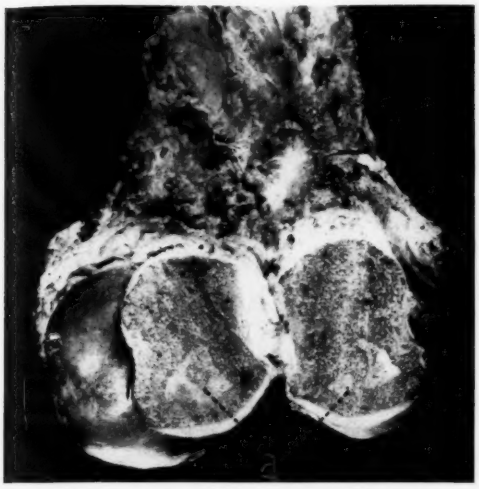


Fig. 8. Case 1. Coronal section of posterior portion of external condyle of right femur, showing calcified necrotic area.

from the synovial lining. The head was flattened and conical in shape although less pronounced than on the left side. There was an osteocartilaginous body attached by a thin pedicle to the inferior portion of the capsule. Articular cartilages were destroyed on the superior surface of head and opposing surface of the acetabulum and there were marginal osteophytes on both head and acetabulum.

Coronal sections were made of the right femur (Fig. 7) and iliac bone extending through the acetabulum. Section of the acetabulum showed sclerosis of the bone bordering on the articulation to a depth of 1 to 2 centimeters and two cavities ½ and ⅔ centimeter in diameter in the weight-bearing region. One was filled with fibrous tissue and one with fluid (Fig. 12). There were also marginal osteophytes. The bone away from the acetabulum was normal in appearance. Section of the femur showed loss of articular cartilage on the weight-bearing portion of the head, with only a thin layer along the inferior portion. The underlying cancellous bone was sclerotic and contained several small cavities, some filled with fibrous tissue and some with fluid. A yellowish dark area at the base of the upper part of the neck of the femur appeared to be calcified infarct. The cortex and medullary portions of the shaft from there down to the middle had a normal appearance. In the lower half of the shaft there was a necrotic area with a dense surrounding zone of demarcation of approximately the same size and location as that seen in the left femur. The roentgenogram revealed a dense mottled area in the posterior part of the external condyle of the right femur. A section through this region (Fig. 8) revealed a yellowish, hard, amorphous blotchy area averaging 1½ centimeters in diameter which also looked like a necrotic calcified region. The epiphysis otherwise and the knee joint were normal in appearance.

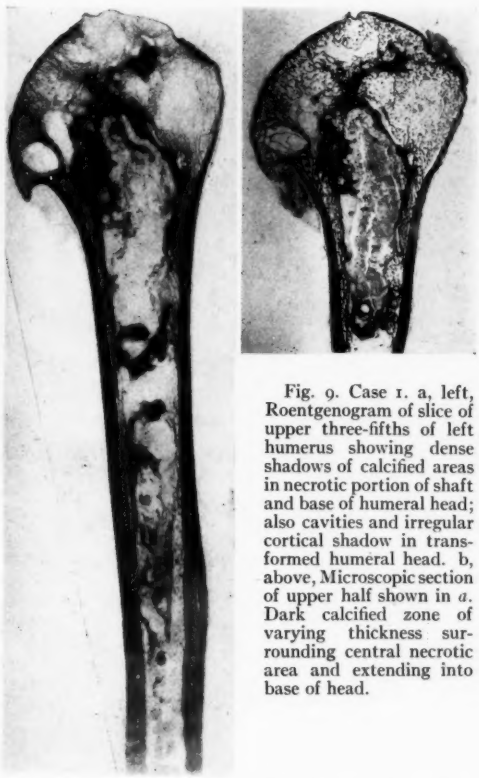
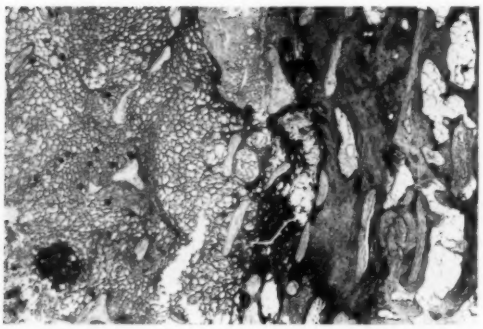


Fig. 9. Case 1. a, left, Roentgenogram of slice of upper three-fifths of left humerus showing dense shadows of calcified areas in necrotic portion of shaft and base of humeral head; also cavities and irregular cortical shadow in transformed humeral head. b, above, Microscopic section of upper half shown in *a*. Dark calcified zone of varying thickness surrounding central necrotic area and extending into base of head.

The left tibia was normal in external appearance. On section a mottled, grayish yellow, blotchy streak was found in the medullary cavity of the shaft 10 centimeters below the upper end of the bone. There was also an irregular area of slight sclerosis in the cancellous bone of the lateral portion 2 centimeters below the epiphyseal line.

Slices ½ to 1 centimeter thick were cut from the upper three-fifths of the left humerus, the left glenoid, the upper two-fifths of the left tibia, the entire length of the femurs and the acetabula and iliac bones. Roentgenograms of the slices brought out sharply the dense zones of demarcation about the necrotic areas and the blotchy areas of increased density irregularly distributed within them, also the subarticular sclerosis and cavities in the femoral and humeral heads. Large microscopic sections were prepared of the slices of bone, also sections were made of the villous linings of the shoulder and hip joints and of one of the loose bodies which were present in the shoulder.



1 2 3

Fig. 10. Case 1. Section of wall about necrotic area in Figure 9, b, showing, 1, necrotic bone and marrow with calcareous islands; 2, fibrosed, calcified and partly ossified wall; 3, surrounding living cancellous bone and marrow.

Figure 9 shows the appearance of the roentgenogram of the slice cut from the humerus and of a microscopic section of the upper half of the slice. Under the microscope the central region of the shaft was found to consist of necrotic cancellous bone and marrow with blotchy areas of calcification. About the upper and lower limits of the necrotic area there was a broad layer of heavily calcified connective tissue and débris. Along the sides the zone of demarcation was much narrower. The lateral wall consisted of a narrow zone of calcified tissue in its upper three-fourths and of uncalcified dense fibrous tissue in its lower fourth. There was also an uncalcified fibrous wall along the lower two-thirds of the mesial wall. Surrounding this zone were living cancellous bone and fatty marrow. A microscopic section of the calcified lateral wall is shown in Figure 10. The internal portion consisted of small trabeculæ with empty lacunæ and of necrotic marrow. The outlines of the dead fat cells were remarkably well preserved. They were generally filled with an albuminous substance (edema *ex vacuo*). There were in places large and small calcareous granules. The zone of demarcation consisted of fibrous tissue which was extensively calcified and in places had been transformed into bone. It incorporated some dead trabeculæ which had not yet been absorbed and replaced by new bone. Outside of this was living cancellous bone and fatty marrow. The humeral head was flattened and contained three cystic areas —two in its lower part and one in its upper part. They were filled partly with a coagulum and partly with fibrous tissue. The joint surface of the superior and lateral portion of the head was covered with normal articular cartilage and underlying cortex. The rest of the head was covered with an incomplete thin layer of fibrocartilage and the articular cortex was bare and sclerosed in places. There was an osteophyte at the lower limit of the articular surface and a notch at the junction of the normal and transformed articular surfaces at the top of the head.

Fig. 11. Case 1. Roentgenogram of slice of right femur and acetabulum showing arthritis deformans and walled off infarct in lower half of femoral shaft.

Numerous villi sprang from the synovia. At the base of the head in its upper portion a partly transformed calcified necrotic zone separated it from the greater tuberosity.

The changes in the head are best explainable on the basis of a massive necrosis of all except its superior and lateral portion with death of overlying articular cartilage. The subsequent changes have consisted in gradual invasion, absorption, and replacement of the necrotic portion by cancellous bone and cystic cavities, and calcified tissue at its base. The dead articular cartilage has been partly replaced by an incomplete layer of thin fibro-

Fig. 12. Case 1. Microscopic section of the upper portion of the right femur and of the acetabulum showing deforming arthritis.

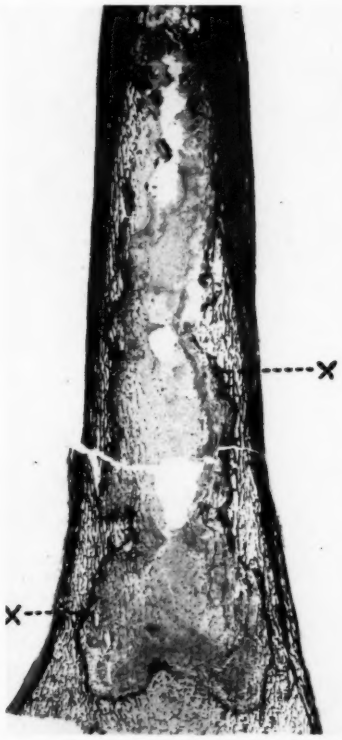


Fig. 13. Case 1. Microscopic section of lower half of shaft of right femur showing central necrotic area and calcified zone, *x*, about its periphery.

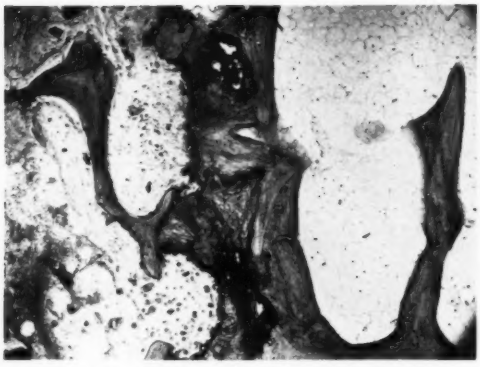
cartilage. These changes gave rise secondarily to villous synovitis and osteocartilaginous loose bodies. A section of one of the loose bodies showed it to consist of a center of calcified fibrocartilage and an outer portion of irregularly laminated fibrocartilage and calcified cartilage

Figure 11 is a roentgenogram of coronal slices of the right femur and acetabulum and Figure 12 a microscopic section of the upper portion of the femur and acetabulum.

The changes in the head of the femur and acetabulum were similar to those in the head of the humerus. Microscopically, the articular surfaces on both sides of the joint were covered by an irregular layer of fibrocartilage. In places it was incomplete and bare sclerosed bone with fibrous marrow bordered on the joint. There were subchondral cavities filled with fibrous tissue or with coagulum and there was marked osteophyte formation at the limits of the articular surfaces. The synovia showed a villous arthritis and there was a small island of bone imbedded in capsule at the inferior portion of the joint. At the base of the neck both mesially and laterally there were irregular islands of calcified fibrous marrow indicative of ancient bone necrosis. The head presented the picture of ancient aseptic necrosis with secondary collapse, invasion, and transformation similar to that which has been observed following intracapsular fracture of the neck with necrosis of the head, bony union of the fracture and subsequent weight bearing.

The rest of the upper diaphysis showed no change.

Microscopic examination of a section of the lower half of the shaft of the right femur (Fig. 13) revealed a central area of necrosis of cancellous bone and marrow with a small amount of granular calcification similar to that seen in the upper diaphysis of the humerus. The dead trabeculæ were unaltered in form as can be seen in Figure 12. There was a surrounding narrow zone of demarcation of calcified and partly ossified connective tissue. In places the connective tissue had grown for short distances into the necrotic zone, and in the upper limits were broad bands and islands of calcified tissue. There was a surrounding zone of living trabeculated bone and marrow, except at the upper end where the calcified



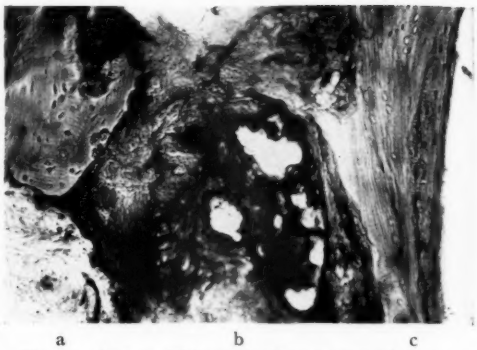
a b c

Fig. 14. Case 1. Wall of necrotic area: a, Necrotic bone and marrow within; b, calcified fibrous zone of demarcation; c, surrounding living cancellous bone and marrow. ×25.

wall merged with the compact cortex laterally. Figures 14 and 15 show the microscopic appearance of the zone of demarcation.

The articular cartilage and synovial lining of the knee joint were normal, which would indicate that the necrotic lesion did not primarily reach the articular surface of the joint. A microscopic section of the yellowish dense area in the posterior part of the external condyle showed it to consist in its deeper portions of old dead bone with cancellous spaces filled with a partly calcified sparsely cellular connective tissue. In its peripheral portion were living bony trabeculæ and the lesion was surrounded by living cancellous bone and fatty marrow. Microscopic examination of the yellowish dense area in the upper third of the shaft of the left tibia showed a picture similar to that in the external condyle of the femur. These were obviously old areas of necrosis with fibrous invasion, calcification, and incomplete replacement by new bone. The one in the condyle of the femur appeared to be an infarct which arose separate from that in the diaphysis.

Case 2. L. O'B., aged 37 years, was admitted to the Veterans' Administration, Dayton, Ohio, in June, 1934, because of pain and stiffness in both hips of 4 years' duration. He states that in 1930 while working in a caisson there was leakage of gas from a neighboring plant and the crew was hurriedly taken out without gradual decompression. The patient developed the "bends" and was placed in a recompressor. On removal the attacks recurred so that he was returned to the recompressor and kept for 1 day. He was sent to a hospital with bleeding from the ears, nose, and mouth, and delirium which necessitated restraint. Ecchymoses developed in the skin of various parts of the body. He has had pain in the hips and legs from the time of admission to the hospital to the present although in diminishing severity, also some pain and stiffness in the shoulders. In 1931 he went into compressed air again to see if it would benefit his hips. He thought the pressure affected his heart and the joints were not benefited. The pain and stiffness in the hips have advanced to a point where he has had to discontinue all work.



a b c

Fig. 15. Case 1. High power view of zone of demarcation. a, Necrotic border; b, calcified zone; c, surrounding living bone.

Past history. He was a steam fitter before being a caisson worker. He has had the usual diseases of childhood, and smallpox, influenza, and pneumonia; gonorrhea in 1923. He denies having syphilis. No history of joint trouble was elicited before the onset of the caisson disease. He suffers from headaches and attacks of dizziness. He smokes and drinks alcoholics moderately.

Physical examination. The patient is short, stocky, and somewhat overweight. He walks carefully with a waddling gait. Regional examination is essentially negative aside from the hips and shoulders. There is slight limitation of motion in both shoulders, more marked in the left. Motion in the hips is limited in all directions to about one-half normal and forced motion is painful. There is normal range of motion in the ankles and knees.

Laboratory findings. Basal metabolic rate was −10; blood Wassermann and Kahn, negative. Cytology and chemistry of blood, analyses including calcium, phosphorus, and uric acid, were within normal limits.

Roentgenograms were taken of the hips (Fig. 16). The head of the left femur showed a large spherical area of mottled density in the weight-bearing portion, including the joint surface and extending to the junction with the neck. It was separated from the surrounding bone by a broad zone of reduced density and its articular surface was depressed 3 to 4 millimeters. The rest of the articular surface of the head and that of the acetabulum appeared even in outline, and the cartilage space was of normal width. The mesial and inferior portions of the head were slightly increased in density and there was haziness and slight increase in density of the bone surrounding the demarcated spherical area, and extending downward into the adjacent portion of neck.

The right femur showed a similar area in the same region of the head which was larger, more dense, and

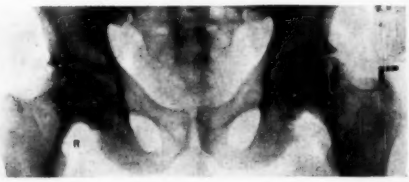


Fig. 16.

Fig. 16. Case 2. Necrosis of heads of femurs in caisson disease of 4 years' duration with sequestration of superior portions from weight bearing.

Fig. 17. Case 2. Left shoulder. Large portion of head of humerus shows irregular reduction in density with zone of increased density about it.

Fig. 17.

less demarcated from the surrounding head by the zone of reduced density. Its articular surface was dense, smooth, and depressed mesially where it extended to the fovea. The bone of the head and neck surrounding the demarcated area was somewhat mottled and increased in density. The shadow of articular cortex of acetabulum was intact and the cartilage space of the joint was approximately normal in width.

Roentgenograms of the shoulder showed blotchy reduction in density with a surrounding zone of increased density in the head of each humerus, more marked in the left (Fig. 17).

The diagnosis was made of caisson disease producing large areas of aseptic necrosis in the heads of the femurs, which, as a result of too much weight bearing, had been separated from the surrounding living bone. A biopsy was performed of the left hip by Dr. Walker. The cartilage looked pale. With a gouge some bone was removed from the neck of the femur. Aerobic and anaerobic cultures and guinea pig inoculations for tuberculosis gave negative results. Evidently the lesion of the head was not entered as microscopic sections of the bone removed showed atrophic living bone with an increase of fat and in some places of fibroblasts in the marrow spaces.

The patient remained in the institution with little change in his condition. February 9, 1935, a roentgenogram of the hips showed slight progression of the disease, the separated area of the head of the right femur being slightly more depressed. May 1, 1935, because of continued pain in the right hip an operation was performed at which cartilage and necrotic bone were removed, reducing the head to about one-fourth its normal size. Microscopic sections were made of a piece of the excised head. It contained bony trabeculæ, the lacunæ of which were entirely devoid of cells. The marrow spaces were partly filled with white fibrous connective tissue much of which was necrotic and in places the bone was being eroded along its surface. The microscopic picture was that of aseptic necrosis of bone with subsequent invasion and partial absorption by connective tissue. The patient after a few months walked in a caliper splint but the joint continued to be weak and painful and he was unable to work. A roentgenogram of the left hip taken 3 years after the first showed only slight progression of the process.

CASE 3. B. W., male, aged 54 years, was admitted to the University of Chicago Clinics, January 3, 1938, because of spastic paralysis in the lower extremities. In 1908 while working at bridge construction he came out of a caisson of 40 pounds' pressure in 5 minutes. Twenty minutes later he suffered severe pains in the abdomen, arms, and legs, and was removed to a hospital. There he developed in addition paralysis of the lower extremities and bladder and was confined for 4 months. The pains gradually disappeared but the limbs remained weak and became spastic.

Since 5 months after the injury the patient had walked with a cane but always with great difficulty. Sexual impotence had been present since the injury. He had had no pains in the limbs until 2 years ago since which time there had been frequently a dull ache, especially at night, over the lower half of the right tibia.

Past history. Patient could not recall any case of illness before accident in 1908; no history of venereal infection.

Physical examination revealed a well nourished male, weight 200 pounds; blood pressure, 150/90. Regional examination aside from the lower extremities was essentially normal, except for the right pupil which was slightly larger than the left and both pupils reacted sluggishly to light. He walked slowly with a spastic gait. Both lower extremities were spastic and movements of the joints were carried out with difficulty. The patellar and Achilles reflexes were exaggerated and clonus was easily incited. The hip, knee, and ankle joints showed no palpable changes but motion was restricted in them due to the spasticity. There was hypesthesia and marked dimi-

Fig. 18. Case 3. Walled off zones of increased density within shafts of right femur and tibia.

Fig. 19, left. Case 3. Demarcated dense zones in upper portions of right tibia and fibula.

Fig. 20, right. Case 3. Right tibia and fibula. Lower metaphysis involved in tibia and free in fibula.

nution in tactile sense below the knees. Blood Wassermann 4 plus, Kahn 3 plus.

Roentgenograms were made of the entire skeleton. Areas of increased density were revealed within the shafts of the lower ends of the femurs, the upper ends of the fibulas, and the upper and lower ends of the tibias. In the right femur the lower three-fifths of the shaft was involved. There was a dense irregular zone of demarcation at the junction of the cancellous and cortical bone of the metaphysis and irregularly along the walls of the medullary cavity above (Fig. 18). A similar condition was seen in the upper third of the shaft of the right tibia and in the upper metaphysis of the right fibula (Fig. 19). There was a similar dense blotchy area in the lower end of the right tibia 6 centimeters long beginning 1½ centimeters above the epiphyseal line (Fig. 20). In the left femur the involvement began just above the lower epiphysis and extended upward throughout three-fifths of the shaft (Fig. 21). The lesions in the left tibia and fibula resembled those of the right (Figs. 22 and 23). The left humerus showed a pointed area of increased density in the region of the lesser tubercle. There was no change in the head of the humerus or shoulder joint (Fig. 24). Roentgenograms of the rest of the skeleton revealed no abnormal changes. It was particularly noteworthy that the heads of the femurs and hip joints were uninvolved.

Diagnosis. The condition was diagnosed as a late stage of caisson disease with spastic paraplegia of the lower extremities and areas of incompletely resolved and calcified aseptic necrosis of the femurs, tibias, fibulas, and left humerus. Lues was diagnosed because of the positive Wassermann and Kahn tests and the sluggishness and inequality of pupils. But the roentgenographic appearance of the bone lesions

Fig. 21.

Fig. 22.

Fig. 21. Case 3. Demarcated zone and dense areas within shaft of left femur.

Fig. 22. Case 3. Upper end left tibia. Involved area densest about periphery. Involved fibula equally dense throughout.

Fig. 23. Case 3. Both ends left tibia and upper end of fibula involved.

Fig. 23.

was like that of Case 1 and very different from that seen in bone syphilis. No treatment was advised for the caisson disease but treatment was recommended for the lues.

CASE 4. L. P., male, aged 55 years, entered the University of Chicago Clinics, April 11, 1938, because of long-standing stiffness and pains in the hips, knees, and shoulders. In February, 1917, the patient worked for 8 hours in a caisson with pressure of 20 pounds. He came out in 4 minutes and 30 minutes later developed severe pains in the abdomen, legs, and arms. He had hemoptysis and hematemesis and was very ill for several days. He gradually improved and in 3 months was able to work but still had pains in both upper and lower extremities. Five months after the accident he had to give up work because of stiffness and soreness in the hips. These symptoms have persisted and he has gotten around with increasing difficulty. Pain and stiffness in the shoulder have also continued. Swelling developed in the lower legs and the skin became discolored with the development of leg ulcers. He has been unable to do any kind of work for several years.

Past history disclosed the usual diseases of childhood and gonorrhea at 19 years.

Physical examination revealed a well nourished male who moved about with great difficulty. Regional examination was essentially negative aside from the extremities. There was limitation of elevation of the arms to about 90 degrees and forced motions caused pain in the shoulders; marked

Fig. 24. Case 3. Blotchy dense area in metaphysis of humerus. Head and shoulder joint unchanged.

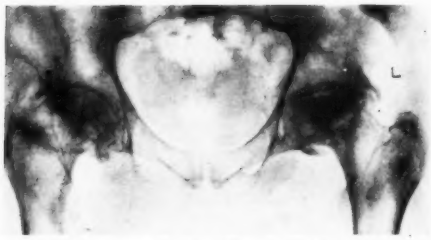


Fig. 25. Case 4. Left hip deformed with sequestrum at top of flattened transformed femoral head. In right hip are noted osteophytes and mottled density of head.

limitation of motion in all directions in both hips; knee and ankle motion was slightly limited.

Moderate swelling of the lower half of the legs was noted and also brawny induration, pigmentation, and small ulceration of the skin were present. Little muscle weakness was found in the legs and forearms. The reflexes were normal throughout. No disturbance of sensation of the skin was noted in any part of the body. Blood pressure was 130/76. Urine and blood examinations were essentially negative. Wassermann and Kahn tests were negative.

Roentgenograms were made of the entire skeleton. Extreme deformity of both hips was noted, more marked in the left (Fig. 25). The head of the left femur was flattened and the underlying bone was irregularly increased in density. The depressed dense area at the middle of the top appeared to be a detached piece of necrotic cortex such as is often seen in the collapsed femoral head that is necrotic following traumatic dislocation of the hip, fracture of the neck of femur, slipped epiphysis or Legg-Perthes' disease. The cartilage space of the joint was narrowed and there was marked osteophyte formation at the acetabular margins. The right hip showed narrowing of the cartilage space of the joint, increased density, and mottling of the head of the femur and lipping of the lower articular margins of the head and of the upper margin of the acetabulum. There was a half-moon shaped shadow of blotchy increased density in the upper portion of the head of the left humerus bordering on the articular surface which was irregular in this region (Fig. 26). The greatest increase in density was at the junction of head and neck and there was a narrow, irregular streak of increased density extending downward for approximately 3 centimeters into the shaft. The right humerus showed a similarly situated area of increased density which was more uniform and the articular surface of the area was somewhat irregular and flattened. The process did not extend into the shaft of the humerus.

Somewhat hazily outlined areas of increased density were apparent in the interior of the diaphyses of the lower ends of the femurs, both ends of the tibias and questionably the proximal ends of the fibulas, as seen in Figures 27, 28, and 29. The appearance differed from that of the corresponding

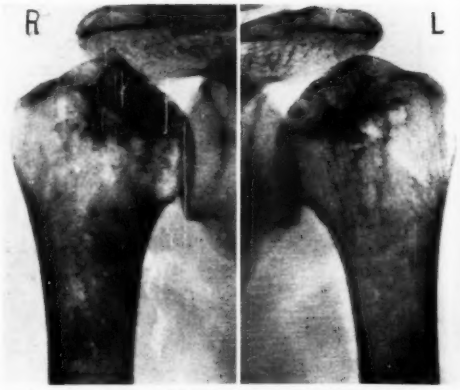


Fig. 26. Case 4. Mottled increased density in head of each humerus with extension into metaphysis of left.

leg bones in Cases 1 and 3 in that dense lines of demarcation had not yet formed about the periphery of the lesions. The epiphyses of all three bones were free of involvement and no changes appeared in the joint spaces.

A *diagnosis* was made of caisson disease with necrosis and partial replacement by new bone and partial calcification in the heads of the humeruses and femurs and necrosis with less complete reorganization and calcification in the diaphyses of femurs and tibias.

In view of the similarity of roentgenographic changes in the bones and joints in the 4 cases and of the established nature of the pathology in Cases 1 and 2, the evidence appears to be conclusive that the primary lesion is an accumulation of nitrogen gas in the bones—whether intravascular or extravascular will be discussed later—with interference of circulation and a resultant massive aseptic necrosis. In the head of femur or humerus the necrotic lesions may break down and be invaded and eventually replaced by new bone or fibrous tissue. Invasion of portions of the epiphysis may be followed by calcification and arrested transformation, especially in portions of the epiphysis away from the articular surface. Involvement of articular cortex and cartilage leads to the slow development of arthritis deformans with or without osteocartilaginous loose bodies. These changes are in keeping with those seen in the head of the femur and hip joint years after interruption of blood supply of the head of femur as by slipped epiphysis, certain cases of traumatic disloca-

Fig. 27.

Fig. 28.

Fig. 29.

Fig. 27. Case 4. Central involved areas in shafts of right femur, tibia, and fibula hazy in outline and slightly increased in density.

Fig. 28. Case 4. Hazily outlined central increased density in shaft of femur, greatest in metaphysis.

Fig. 29. Case 4. Blotchy dense areas in medullary canal and metaphysis of tibia.

tion of the hip, fracture of the neck of the femur followed by bony union (Phemister) and idiopathic necrosis in adults (Chandler).

The lesions in the shafts are remarkable in that they are much more numerous and extensive than in any case of bland infarction or aseptic necrosis of bone found reported. The necrosis was of the interior of the diaphysis in all instances and because of the long time that had elapsed since the initial lesion it was difficult to know how much if any of the internal portion of cortex was involved. Creeping invasion and substitution of the dead bone by new bone may have reduced materially the size of the necrotic area before the process came to a standstill with calcification of the surrounding fibrous zone. Preservation of circulation to the cortex would tend to guard against the occurrence of pathological fracture but the presence of central necrosis producing weakness of bone would set up a reparative stimulus leading to creeping replacement of some of the dead bone by new bone. Once the diaphysis is sufficiently strong to support the part, the stimulus for substitution would come to a standstill and the remaining portion become incapsulated. One reason why these large diaphyseal lesions have not been heretofore recognized may be the slightness or absence of associated symptoms and the failure of occurrence of pathological fractures. On the other hand, the pains in the limbs during both early and later stages are doubtless due in some cases to the bone necrosis.

It is difficult to state whether the lesions in the bones produced by the nitrogen gas were the result of nitrogen embolism or of nitrogen accumulation within the medullary cavity and direct compression of blood vessels and other tissues or a combination of the two. Lesions of the soft parts are known to be produced by both methods. Points in favor of nitrogen embolism are: (1) The lesions were frequent (in three cases) in the heads of femurs where end arteries are known to be frequently found; (2) the metaphyses of the lower end of the femur and of upper end of fibula and both ends of tibia were affected in some cases while their epiphyses escaped,

which would favor embolism of the branches of their nutrient arteries. Points against the embolic theory are: (1) The enormous size and symmetrical distribution of the necrotic areas. With such extensive infarction of the bones produced by embolism, similar infarction of the spleen and kidneys might be expected and this was not found at autopsy in Case 1. Also, in the presence of such extensive embolism of bones, death might be expected to result from embolism of soft parts supplied by end arteries as brain, lungs, kidneys, intestine, etc. (2) Absence of involvement of the bones of the trunk.

In favor of the local pressure on blood vessels and other tissues of nitrogen gas accumulated in the medullary cavities is the limitation of the process to the extremity bones. The extremity bones are rich in fatty marrow while the trunk bones which have higher temperatures than the extremity bones (Huggins and Blocksom) contain hematopoietic marrow. Since fats and lipoids are known to absorb approximately five times as much nitrogen as other tissues, more nitrogen should be liberated within the extremity bones than within the trunk bones in caisson disease. Bornstein drew attention to the fact that the sluggishness of circulation in the bone marrow would mean less rapid removal of the gas from the bone marrow than from other tissues and consequently greater likelihood of necrosis from prolonged pressure. Larsen has shown that when a hydrostatic pressure of 180 centimeters or more is maintained in the medullary canal of the femur of the dog, by means of an infusion flask connected with a cannula passing through the cortex, massive diaphyseal necrosis of the medullary tissues and the cortex takes place.

Experience in the treatment of aseptic necrosis of the head of the femur in fractures of the neck with bony union, Legg-Perthes' disease, and slipped epiphysis indicates that the best possible management of any form of necrosing lesion of the head of the femur (including caisson disease necrosis) is prolonged abstinence from weight bearing, thus permitting reorganization of the necrotic area, and if possible replacement by new bone with the avoidance of collapse of the head.

ANIMAL EXPERIMENTS

A search of the literature on experimental caisson disease failed to reveal a report of examination of the skeleton for evidences of lesions produced by liberated nitrogen gas.

Experiments on Dogs

One of us (D.B.P.) in the department of surgery of the University of Chicago attempted to produce bone necrosis on seven dogs by arterial air embolism in the following manner: The dogs were anesthetized with ether and the head lowered in extreme Trendelenburg position. Aseptic technique was used and the right femoral artery was exposed and ligated. An arterial clamp was applied 1 inch above and the artery was opened near the ligature. A ureteral catheter, large enough to fill the artery, was introduced and, after removal of the clamp, pushed upward until its tip was in the aorta just above the bifurcation. Air varying in amounts from 6.7 to 12 cubic centimeters per kilogram body weight was then slowly injected. The air passing into the arteries produced crepitation in the lower extremities. After the wounds were closed the surviving animals were left in the Trendelenburg position for 3 hours to decrease the amount of air embolism in heart, lungs, and brain and to prolong that in the lower extremities.

Protocols of Experiments

Seven cubic centimeters per kilogram body weight injected in one dog caused paralysis in the hind legs; death in 7 days. The femurs and tibias were split longitudinally and no gross changes were observed. Microscopic sections of upper end of left femur showed no abnormalities.

Eight cubic centimeters per kilogram body weight injected in one dog caused partial paralysis of hind legs. Infection developed in the operative wound and killed the dog in 8 days. Bones of both hind limbs were split open. No gross evidence of necrosis was seen anywhere.

Ten cubic centimeters per kilogram body weight injected in one dog produced partial paralysis in the hind legs which slowly improved to some extent. Death occurred from distemper in 78 days. The bones of the hind legs were removed, roentgenographed, and split open. A microscopic section was made of the upper end of the femur. No x-ray, gross, or microscopic change was found.

Ten cubic centimeters per kilogram body weight injected into one dog produced complete paralysis

and contractures of the hind limbs. Animal was sacrificed in 155 days. The spinal cord was examined by Dr. Cloward. It showed marked degeneration in distribution of anterior spinal artery of lumbosacral region. The muscles of the hind limbs were dissected from the skeleton. In places they were pale and shrunken, especially the adductors. Microscopic sections showed extensive-scattered replacement by fat. The bones of the hind limbs were roentgenographed, split open, and the left femoral head was sectioned for microscopic study. No changes were found aside from slight atrophy.

Twelve cubic centimeters per kilogram body weight injected in one dog caused death in 10 minutes from embolism.

Ten cubic centimeters per kilogram body weight injected in another animal caused death over night from embolism.

Six and seven-tenths cubic centimeters per kilogram body weight injected in one dog caused no symptoms afterward. Animal was sacrificed in 94 days. The bones of the hind limbs were roentgenographed and split and microscopic sections were made of the head of left femur. No pathological changes were found in the bones.

The absence of necrosis in the bones of the 4 dogs whose hind limbs were partly or completely paralyzed by the air embolism may possibly be considered as evidence favoring the view that the bone lesions in caisson disease are due rather to gas liberated in the medullary cavity under sufficient pressure to asphyxiate the tissues than to embolism.

SUMMARY

The literature of skeletal lesions of caisson disease is reviewed.

Four cases of caisson disease of long standing in adult males are reported in which there was evidence that multiple infarction of large to small portions of long bones occurred as a result of damage by liberated nitrogen gas. All cases were studied clinically and roentgenologically, and the diagnosis was confirmed in one case by autopsy and in another by biopsy.

Late changes in the necrotic areas varied with the location and duration of involvement.

When the necrotic bone was situated in the epiphyses and bordered on joints, varying amounts of collapse of the weight-bearing portions, invasion and replacement by new bone, and calcification of non-substituted portions were noted. Articular cartilage overlying involved areas broke down and was replaced by fibrocartilage and more or less extensive arthritis deformans was established, accompanied in some instances by the formation of osteocartilaginous loose bodies. Support is furnished for the theory that arthritis deformans may be due to vascular blockage and necrosis of bone underlying articular cartilage.

When the necrotic bone was situated in the diaphyses or in epiphyses away from the articular surfaces, collapse did not occur and there was evidence of some invasion and replacement by new bone, as judged by the presence of irregular cancellous living bone surrounding and even penetrating the persistent areas. Complete replacement of some of the smaller areas had probably come about. But in the case of large areas replacement after advancing to the point of restoring approximately normal strength to the bone, came to a standstill as shown by repeated roentgenographic studies at long intervals, and the fibrous wall about them became more or less extensively calcified and ossified. Small necrotic areas were found, as one in the femoral condyle, invaded by connective tissue and extensively calcified. Scattered calcification also took place to some extent in the large central uninvaded encapsulated areas.

The encapsulated and calcified areas of necrosis in the diaphyses produced characteristic pictures in roentgenograms.

Uncertainty prevails as to whether the necrosis was produced by nitrogen gas obstruction of end arteries of the bones by embolism or by direct pressure on blood vessels and other tissues after liberation from solution in the fat of the bone marrow or in some other unexplained way. The facts that the long bones of the extremities, which are rich in fatty marrow, were the only bones involved, that fat absorbs relatively very large amounts of nitrogen and that nitrogen bubbles would be absorbed slowly from the marrow tissues because of the known sluggishness of the intra-osseous circulation, favor the theory of direct pressure of the gas on vessels and other tissues within the bone. But the extensive involvement of the diaphyses in some cases without involvement of epiphyses, and the involvement of the epiphyses, especially of the head of the femur, without involvement of

diaphyses or without continuity of involved regions in epiphysis and diaphysis are points in favor of infarction produced by nitrogen gas embolism or some other form of intravascular obstruction. Experimental air embolism of the lower limbs of dogs failed to produce bone necrosis.

BIBLIOGRAPHY

1. Bassoe, Peter. Compressed air disease. J. Nerv. & Ment. Dis., 1911, 38: 368–369.
2. Idem. Report of Commission on Occupational Diseases of Illinois, Chicago, 1911. Abstr. in J. Nerv. & Ment. Dis., June 1911.
3. Idem. The late manifestations of compressed air disease. Am. J. M. Sc., 1913, 145: 526.
4. Bert, Paul. Compt. rend., 1871, 73: 213, 503.
5. Bohr and Henriques. Quoted by Steehlin. Handbuch der Innere Medicine. Vol. 4, (part 2). Berlin: J. Springer, 1927.
6. Bornstein. Versuche ueber die Prophylaxe der Pressluftkrankheit. Berl. klin. Wchnschr., 1910, 47: 1272.
7. Idem. Physiologie und Pathologie des Lebens im Verdrichteter Luft. Berl. klin. Wchnschr., 1914, 51: 922.
8. Bornstein and Plate, E. Ueber chronische Gelenkveraenderungen entstanden durch Pressluferkrankung. Fortschr. a. d. Geb. d. Roentgenstrahlen, 1911–1912, 18: 197.
9. Boycott, A. E., Damant, G. C. C., and Haldane, J. S. The prevention of compressed air disease. J. Hyg., 1908, 8: 342.
10. Burkhardt. Arthritis Deformans und chr. Gelenkerkrankungen, 1932.
11. Chandler, Fremont. Aseptic necrosis of the head of the femur. Wisconsin State M. J., 1936, 35: 600.
12. Christ, A. Ueber caisson Krankheit mit besonderer beruecksichtigung einer typischen Erkrankung des Hueftgelenkes. Deutsche Ztschr. f. Chir., 1934, 243: 132.
13. Heller, Mager, and Schrotter. Luftdruckerkrankung. Vienna, 1900.
14. Huggins, C. B., and Blocksom, B. Changes in outlying bone marrow accompanying a local increase of temperature within physiological limits. J. Exper. Med., 1936, 64: 253.
15. Larsen, Ralph M. Intramedullary pressure with particular reference to massive diaphyseal bone necrosis. Ann. Surg., 1938, 108: 127.
16. Phemister, D. B. Fractures of neck of femur, dislocations of hip, and obscure vascular disturbances producing aseptic necrosis of head of femur. Surg., Gynec. & Obst., 1934, 59: 415.
17. Plate, Ehrich. Arthritis Deformans des Huftgelenks enstanden durch Pressluftwirkung nebst Betrachtungen ueber das Zustandekommen solcher Erkrankungen. Arch. f. orthop. u. unfall. Chir., 1928, 26: 201.
18. Twynam, E. G. A case of caisson disease. Prince Alfred Hospital, Sydney, N. S. W. British M. J., 1888, 1: 190–191.
19. Vernon, H. M. The solubility of air in fats and its relation to caisson disease. Lancet, 1907, 2: 691.

THE EARLY DIAGNOSIS OF CERVICAL CARCINOMA

ANTHONY WOLLNER, M.D., F.A.C.S., New York, New York

THE success of the modern treatment of cervical carcinoma largely depends on the early recognition of the disease. The gratifying results of radiation therapy in cases which come under observation in their early stages therefore make early diagnosis of paramount importance. Cancer propaganda alone, which urges the public to seek medical advice as soon as suspicious symptoms appear, cannot be effective because cervical carcinoma in its early stages is symptomless. How long the cancer may be present before it gives rise to symptoms is unknown. The observations of certain gynecologists (Kermauner, Hinselman, Stahler, and others) that a cervical carcinoma may reach a hopeless stage without producing symptoms, are significant. If it is true that the disease may be in an advanced stage when the first symptoms arise, it is evident that the solution of the problem must involve something more than an appeal to lay women. Nor does more emphasis on the prompt recognition of the early lesion in medical teaching assure definite results. Dietel in Germany studied the histories of a large number of cases of cervical carcinoma and found that in 27 per cent the attending physician was responsible for the delay in treatment, by either failing to recognize the true condition or by neglecting to advise adequate treatment. It is fair to assume that similar conditions prevail in other countries, including this one.

To diagnose a cervical cancer in its symptomless stage may be extremely difficult even for an experienced gynecologist. Carcinoma in its incipiency is characterized by minute histological changes, which usually escape recognition, even during the course of a thorough clinical investigation. New diagnostic methods have been perfected in recent years to stimulate interest in the diagnosis of early lesions on the portio. Hinselman devised a colposcope which permits the visualization of minute details on the portio. This instrument is a valuable contribution to our diagnostic armamentarium, but has limitations which make its universal use impossible. It is expensive, and its application requires considerable time, experience, and skill, even when used by a specialist. Another new diagnostic method, more generally available, is Schiller's iodine test. This is based on the observation that normal squamous epithelial cells contain glycogen, which stains a dark brown color with iodine. Cancer cells possess an excessive glycolytic activity, and therefore do not take the iodine stain. The corollary of this is that areas which remain uncolored after the application of the iodine solution are suspicious of carcinoma. Experience has proved, however, that the iodine paint is by no means a specific test for cancer. It has been found that certain benign changes on the portio may also show a negative staining reaction, and it has been frequently noted that areas which did not stain on one occasion did so on subsequent tests. This observation seems to indicate that the glycogen content of normal cells is subject to physiological variations, probably due to endocrine influences. Despite the fact that the iodine test is not absolutely diagnostic for carcinoma, its application should be encouraged. It is a simple, harmless procedure, which can be universally adopted by the general practitioner and made a part of every routine examination. Such a practice would serve the purpose of focusing the general practitioner's interest on the portio and cervix, and would increase the number of cases referred to specialists for an early definite diagnosis.

At the present time there is no diagnostic method whereby cervical carcinoma can be recognized invariably in its early, symptomless stage. The epidermoid type of cancer often originates in the transition zone, where the squamous epithelium of the portio merges with the columnar epithelium of the cervical mucosa. This area cannot be visualized by inspection through a speculum. When the

From the Department of Gynecology, New York Post-Graduate Hospital. Walter T. Dannreuther, M.D., Director.

Fig. 1. Photomicrograph of specimen from cervix in Case 1.

lesion becomes evident on the portio, a considerable amount of destruction in the cervix has already taken place. The adenocarcinomatous type of cervical neoplasm presents still greater difficulties in early diagnosis. Fortunately, this variety occurs rarely, in about 5 per cent of cases. Adenocarcinoma within the cervical canal may reach an advanced stage without initiating symptoms or being recognizable by inspection or palpation. The introduction of a sound into the cervical canal will be of diagnostic value only in fairly advanced cases. The so called central cervical carcinomas, which originate in the deep structures, are hopeless as far as early diagnosis is concerned.

This short review of the diagnostic possibilities in cases of cervical carcinoma demonstrates their relative inadequacy to insure the early recognition of the disease. There is a developmental period in which only a histological examination will reveal the cellular changes which are characteristic of malignancy. Consequently, if we hope to make a really early exact diagnosis, biopsy material must be obtained from cervices, irrespective of suspicious symptoms.

Three years ago I began a systematic histological study of the cervical mucosa, and my observations were reported in two previous communications (12, 13). In the course of these studies I used two groups of patients. One group consisted of 35 normally menstruating women with apparently normal genitals, and in the histological investigation of the biopsy specimens one case of cervical carcinoma was found, which is reported herewith.

Case 1. A woman 38 years of age came under observation in 1937. She had been married for 15 years, had one child 14, and had had two miscarriages, 12 and 3 years previously. She began to menstruate at the age of 14 years, had normal periods thereafter of two to three days' duration with moderate flow. Her chief complaint was cramplike pains in the right lower abdominal quadrant for the past 2 days. The region of the appendix was tender. Gynecological examination revealed moderately descended vaginal walls, a perfectly normal looking cervix, a uterus of normal size and consistency, freely movable, and the adnexa were negative. The patient consented to a cervical biopsy, and the cervical mucosa was removed in its entirety on the eighteenth day after her previous menstruation. The histological examination revealed a small area near the external os, which was suggestive of carcinoma.

Figure 1 is the photomicrograph taken of this area. The specimen is partially covered by squamous epithelium. At the point of transition into columnar epithelium, epithelial plugs are seen dipping into the underlying stroma. Beneath the surface three islands are seen, which are well defined, surrounded by normal connective tissue. The epithelial cells, contained in the islands, have hyperchromatic nuclei, some reveal plenty of protoplasm; in others the nuclei fill out the whole cell, indicating irregular mitoses. This histological picture is suggestive of carcinoma, but a definite diagnosis could not be made on the basis of these findings. Serial sections were therefore prepared for a more exacting study. Figure 2 represents the same area in a subsequent section. Several epithelial islands are seen, which consist of cells deeper staining than those found in the covering epithelium. Some cells reveal irregular mitoses and show some variations in their size and shape. At the deepest point from the surface, some of the islands are broken up into small clumps and become mingled with the surrounding inflammatory cells. This picture demonstrates a beginning malignant invasion in the stroma, and fulfills all the requirements for the diagnosis of carcinoma. Figure 3 is a photomicrograph of a further section of the same specimen. It visualizes a full blown cervical carcinoma. Near the surface the classical picture of leucoplacia is seen. In the deeper stroma a dense infiltration by small round

Fig. 2. Photomicrograph of a subsequent section obtained in Case 1.

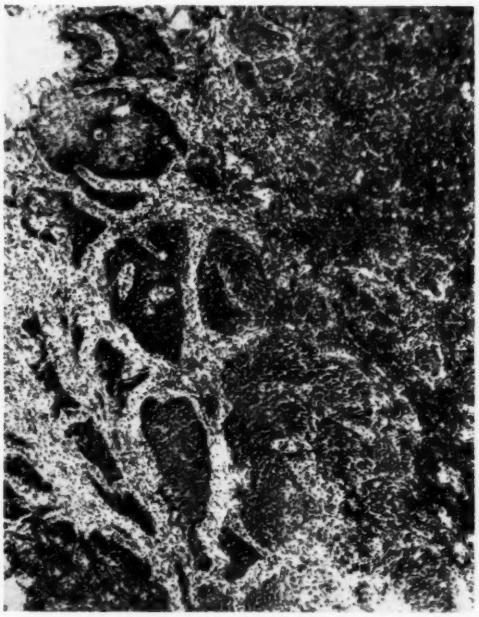


Fig. 3. Photomicrograph of another later section obtained in Case 1.

cells is noted, the epithelial islands are broken up, and there is a deep invasion of the stroma.

This case demonstrates a cervical carcinoma in a patient whose genital organs were subjected to a painstaking study and who was found to be gynecologically normal. The carcinomatous lesion was found accidentally in the course of my studies on the normal cervical mucosa. This observation serves as a good example of the problems in early diagnosis. The histological investigation of serial sections permits a tracing of the gradual evolution of the lesion. On and near the surface of the cervical mucosa well defined islands of metaplastic growth were found, and invasion with the earmarks of carcinoma cells was present in the deep tissue, approximately 2 millimeters beneath the surface. It is evident that the development of such a carcinoma requires considerable time before the destructive process reaches the surface, either on the portio or on the endocervix, and becomes grossly visible.

Another group of patients in whom I undertook a systematic histological study of the cervical mucosa consisted of 24 cases in which clinical symptoms of endocervicitis and erosion were present, and in which the following case of carcinoma was found:

CASE 2. A woman 36 years of age came under observation in 1933. At that time she had been married for 14 years and had three children, 9, 7, and 1 years old, respectively. There was no history of abortions. Menstrual periods began at the age of 13 years, recurred regularly every 28 days, were of 4 to 5 days' duration, with profuse flow. Her chief complaint was profuse white leucorrhea and a bearing down sensation. The gynecological examination revealed markedly descended vaginal walls, a lacerated cervix, which was badly eroded, a uterus of normal size, freely movable, and both adnexa negative. On straining a moderate descensus was noted. I advised a diagnostic curettage, conization of the cervix and plastic repair of the pelvic floor, but the patient did not return until 4 years later. Her condition had then become aggravated. The menstrual periods still came at regular intervals, but were prolonged, of 7 to 8 days' duration, and very profuse. The amount of white discharge had increased, and the bearing-down sensation had become painful. On examination, a second degree of cystorectocele was found. Both lips of the portio were extensively eroded and a

Fig. 4. Photomicrograph of specimen removed in Case 2.

Fig. 5. Area adjacent to that in Figure 4.

sticky cervical discharge was present. The uterus was moderately enlarged, firm, in good position, adnexa negative. This time the patient consented to an operation.

Under ether anesthesia dilatation and curettage were performed. A large amount of pale endometrial tissue was obtained. Conization of the cervix and plastic repair of the cystorectocele were done. The histological examination of the endometrial specimen revealed a marked glandular hyperplasia. Similar findings were noted in the cervical specimen but for a small area near the external os, where an incipient carcinoma was found.

Figure 4 demonstrates this area. The portio is covered with normal stratified epithelium, which abruptly changes at the transition point, where there is a loss of layer formation. The epithelial cells are irregular in size, shape, and staining reaction. The penetrating epithelium separates the cervical glands in some places; in other areas the glands are pushed together and form regular islands in the strand of epithelium. There are places where one finds nests containing typical spindle cells, but having no connection with the surface epithelium. Under high power, irregular mitoses can be seen. This photomicrograph presents the histological picture of an incipient malignancy. An adjacent area to that presented here is visualized in Figure 5. A benign invasion of hyperplastic squamous epithelium into the cervical glands is present. The lumen of the glands is almost completely filled with epithelial cells, transforming some of them into solid islands. A marked proliferation is present in these islands, but they are well demarcated, and the individual cells are uniform, not suggesting malignancy. Some of the islands in the deep stroma contain deeper staining cells and occasional irregular mitoses can be seen under high power.

In this case an incipient cervical carcinoma was found, although the clinical picture intimated only a simple erosion with endocervicitis. Both these reported cases of early malignancy have certain features in common which deserve further discussion. In both, the origin of the growth could definitely be placed in the epithelial transition zone. The generally accepted conception, that cervical cancer originates in this area, is supported by these observations. From the viewpoint of early diagnosis this location is unfortunate. The transition point between squamous and columnar epithelium does not correspond with the clinical designation of the external os. Squamous epithelium sometimes extends far upward in the cervical canal, which places the

transition point beyond the reach of inspection. Furthermore, the lesion's tendency is to penetrate into the deep tissues, consequently, the surface of the endocervix and portio remains intact in the very early stages of the disease. Considering all these facts, it becomes evident that there are neither symptoms nor clinical findings on which to base the diagnosis of cervical carcinoma in the early stage.

Another common feature in both cases is the presence of epithelial metaplastic growths side by side with carcinoma. The interpretation of benign epithelial invasions into the cervical mucosa is a controversial matter. Ribbert in his *Textbook of Pathology*, which was published in 1896, discussing cervical carcinomas, stated that benign epithelial metaplasia is the basis on which carcinoma develops through atypical cell divisions. This conception was widely accepted at that time, and among others, von Franque in 1907 considered leucoplacias as precancerous lesions. Subsequent investigators, however, discarded Ribbert's theory. The now generally accepted view was expressed by Robert Meyer, who believes that epithelial metaplasia is the manifestation of a healing process in erosions. The squamous epithelium growing back to the denuded surface, in its proliferation surrounds and invades the ducts of the glands. This invasion may extend to the deeper layer of the mucosa and some glands may be filled out entirely with squamous epithelial cells. Meyer also believes that these invasive growths eventually become displaced to the surface, where they belong, after the healing process is completed. Recently Hinselman, who made an extensive study of leucoplacias, expressed the opinion that carcinoma cannot develop without a preliminary stage such as leucoplacia.

My observations do not seem to substantiate the conception that epithelial metaplasia is a healing process in the cervical mucosa. In 24 cases of marked erosion I subjected the endocervix to a painstaking histological study. In only 3 instances could I find an evidence of epithelial metaplasia in the specimens. If the healing process were the etiological factor for these benign growths, one would expect the histological picture of epithelial metaplasia to be present in almost every case of erosion.

Recent observations that the biological functions of the cells in the cervical mucosa are under hormonal influences, a fact clearly demonstrated in my previous studies, place the interpretation of metaplastic growths on a new basis. In animal experimentations it has been shown by several investigators (Selye, Thompson and Collip; Overholser and Allen; Engle and Smith; and others) that prolonged administration of follicular hormones exerts a specific stimulation on the epithelial cells of the cervical mucosa. Herold and Effkeman experimented with rats. After the administration of follicular hormones, they observed the crowding out of the normal columnar epithelial linings of the glands by squamous epithelium. After 3 months' treatment some glands were found to be entirely filled with squamous epithelium and conveyed the impression of isolated islands beneath the surface. In castrated rats the epithelial metaplasia occurred after a shorter period of treatment than in normal animals.

In a castrated woman I followed up the histological changes in the cervical mucosa during the administration of estrone, and observed changes in the human cervix identical with those reported in animals. I was able to produce epithelial metaplasia in the human endocervix by prolonged hormone administration, and the disappearance of the metaplastic growths was noted after discontinuance of the hormone therapy. A detailed report of my observations in this case will be made at a later date.

Data are accumulating which prove that epithelial metaplasia in the cervical mucosa is the result of excessive hormonal stimulation. It is of interest to ascertain in the case herein reported whether the histological picture of the endometrial specimen substantiates this contention. We know that excessive follicular hormone production is expressed in the endometrial histology by the production of hyperplasia. An endometrial specimen (Fig. 6) was obtained in Case 2, which case incidentally revealed the most pronounced metaplastic changes in the cervical mucosa. The photomicrograph shows the typical picture of glandular hyperplasia. Portions of the cervical mucosa outside the areas of carcinoma reveal

Fig. 6. An endometrial specimen, Case 2.

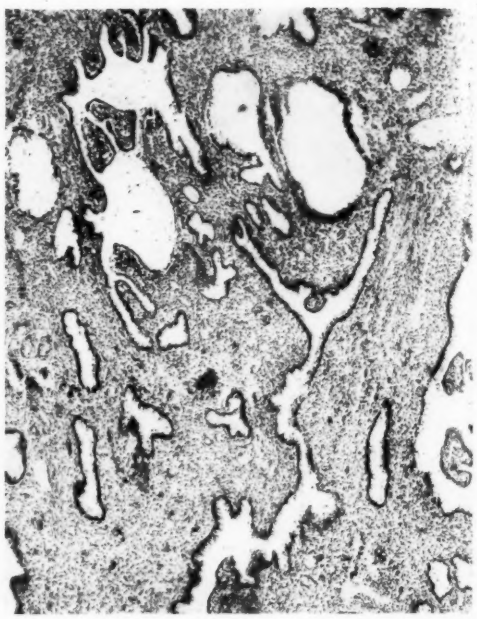


Fig. 7. Cervical specimen showing markedly dilated glands with preserved epithelial lining.

histological changes similar to those found in the endometrium. Figure 7 visualizes the cervical specimen in which numerous markedly dilated glands with well preserved epithelial lining are seen. The picture very much resembles that found in hyperplastic endometria, called the "Swiss cheese pattern." The histological study of both the endometrial and cervical specimens reveals changes which are known to be the result of excessive estrone influence.

In the histological diagnosis of early cervical carcinomas epithelial metaplasia merits special attention. Whenever such a benign epithelial invasion is discovered, it is advisable to subject the specimen to a thorough study by making serial sections. In my 2 cases a gradual transformation of benign epithelial hypertrophy into malignancy was noted. There is a strong indication that epithelial metaplasia developing under hormonal influence constitutes the basis on which carcinoma originates, because of the added stimulus. There really is little difference between carcinoma cells and the normal epithelium. The difference lies chiefly in an altered biological activity, manifested by rapid proliferation. We know that estrone governs the normal proliferation of the epithelial cells, and that its continuous action produces benign epithelial invasions into the glands, which invasion, however, is orderly, never penetrating into the surrounding stroma. The factor which adds the stimulus for unorganized, destructive, invasive growths has not yet been found.

The clinical course of my 2 reported cases deserves to be mentioned. After having established the diagnosis of carcinoma, no further treatment was given these patients. Both of them are regularly reporting for a gynecological follow-up. The first patient has now been observed for 24 months, and the second for 22 months, since the diagnosis of carcinoma was established. Both patients are well, and repeated careful examinations fail to reveal any sign of a lesion in the genital tract. The elapsed time is too short to justify a final opinion, but the implications are that the simple radical excision of the cervical mucosa

apparently removed all of the malignant growth.

IMPORTANCE OF EARLY DIAGNOSIS; METHODS OF OBTAINING BIOPSY SPECIMENS

An early diagnosis of cervical carcinoma is of twofold importance. Of prime importance are the clinical considerations, because early cases yield to irradiation therapy in a gratifying manner, and a cure can be anticipated in a majority of them. There are indications to warrant the hope that in incipient cases a radical excision of the cervical mucosa alone may eradicate the neoplastic process. A case may be regarded as incipient so long as it remains symptomless and clinically unrecognizable, although the diagnosis may be made from histological findings. From a clinical standpoint, it is highly desirable that cervical carcinoma shall be detected and extirpated in its incipiency.

The other factor which makes an early diagnosis of paramount importance is the scientific aspect of the problem. We cannot hope to solve the cancer problem without acquiring exact knowledge of the histological genesis of carcinoma in the human. At the present time there is no clean cut histological definition of carcinoma. Some pathologists consider variations in the size, shape, and staining qualities of the epithelial cells and atypical mitotic figures as carcinomatous, while others are reluctant to make a definite diagnosis of carcinoma unless malignant invasion into the stroma is present. Whether carcinoma is the result of gradual changes in the biological function of the cells is a moot question. It is difficult to draw a sharp line of demarcation between a benign atypical epithelial proliferation and carcinoma. It is logical to assume, however, that if the histological study of a sufficiently large number of incipient cases were possible these questions might be solved eventually. The uterine cervix is an ideal site for such an investigation, as it is easily accessible and permits the taking of biopsies without serious discomfort and unpleasant sequelæ to the patient.

It is unfortunate that the diagnostic histological exploration of the cervical mucosa has not had the attention it deserves. This is particularly true because this structure is the most common site of pathological lesions in the female genital tract. Ninety per cent of uterine carcinomas originate in the cervix. Furthermore, in gynecological practice a normal looking cervix is unusual. Considering these facts, it seems reasonable that the endocervix as a histological unit should receive as much attention as the uterine lining membrane, the endometrium. In the many routine diagnostic curettages the endocervix is hardly, if ever, touched. It must be remembered that a simple scraping of the endocervix with a curette does not provide sufficient tissue for a histological diagnosis. As I pointed out in my previous studies, due to the peculiar anatomical structure of the cervical mucosa, adequate tissue material can be obtained only by excision. For this purpose I have employed the Hyams' conization method (5) during the past 5 years in nearly two hundred cases, and have never observed any untoward aftereffects. If conization is done after dilatation and curettage, it does not add to the discomfort of the patient and does not prolong hospitalization. Routine removal of the cervical mucosa for histological examination should be regarded as a logical procedure in cases in which a diagnostic curettage is indicated.

Cervical pathology is not necessarily manifested by symptoms which would indicate a diagnostic curettage. It has been shown by my 2 cases that the most destructive lesion of all, carcinoma, may develop in a symptomless cervix. The limited number of extremely early cases reported elsewhere in the literature were also found accidentally. Evidently, if a beginning cervical carcinoma is to be discovered in any large number of cases, a routine procedure must be adopted in office gynecology, which permits the taking of cervical biopsies, irrespective of the absence of suspicious symptoms. A method is available, which by its simplicity and safety deserves to be included in our diagnostic armamentarium. For diagnostic purposes it is not necessary to remove the cervical mucosa throughout its entire length, since sufficient observations have proved that cervical carcinoma originates in the lower half of the canal. No early case has been found in the literature to indicate a higher point of origin. I designed cutting wires for coning out

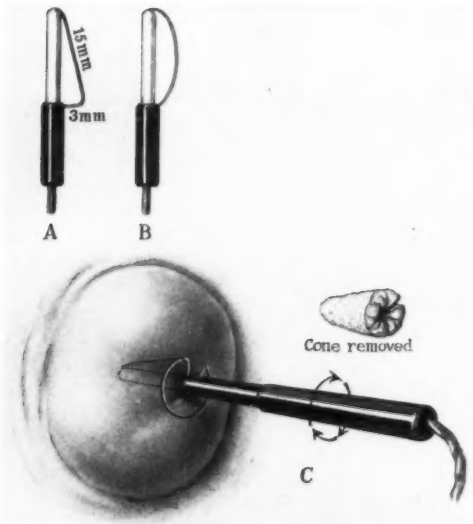


Fig. 8. A, wire used in milliparæ; B, in lacerated cervices; C, instrument in application.

the lower half of the endocervix, which differ from the Hyams conization wires in their size and shape. They are three-quarters of an inch long and are constructed in two different shapes. Figure 8 depicts the electrodes: A, the wire used in nulliparæ and *B* in lacerated cervices, whereas *C* shows the motion by which the specimen is obtained. Employing this method the area near the internal os is avoided, thereby causing less discomfort to the patient, as this region is the most sensitive part of the cervical canal. The circular excision is completed in a few seconds and can be done without anesthesia. The excised specimen is placed in formalin solution for subsequent histological study. The denuded area does not require after-treatments, and re-epithelialization is complete after 3 weeks, without scar tissue formation or subsequent stenosis.

SUMMARY

The present study is based on 59 cases in which a routine removal of the cervical mucosa was done for purposes of a systematic histological investigation. Although none of these cases revealed symptoms or clinical findings which indicated malignancy, in 2 patients definite cervical carcinoma was found. In both cases a simple excision of the endocervix apparently effected a cure. My experiences justify the following recommendations: (1) No diagnostic curettage should be considered complete without removal and histological examination of the cervical mucosa. After dilatation and curettage the Hyams conization offers the simplest and safest way to accomplish this purpose. (2) Every woman past her thirtieth year should be considered a potential candidate for cervical carcinoma. It is advisable for patients in this age group to have at least one routine tissue examination of the lower half of the cervical mucosa. The only contraindication for this procedure is inflammation or tenderness in the adnexa.

I believe that in the present cancer-conscious era it should not be difficult to impress our patients with the advantages of a routine cervical biopsy. Gynecologists who adopt these two recommendations, may be rewarded by the gratifying experience of recognizing and curing an occasional patient with incipient cervical carcinoma. The accumulating histological studies on the lower half of the cervical canal will contribute greatly to a better understanding of the physiological function of a structure which is a common site of carcinoma.

REFERENCES

1. Dietel. Deutsche med. Wchnschr., 1935, 18: 698.
2. Engle and Smith. Anat. Record, 1935, 61: 471.
3. Herold and Effkeman. Zentralbl. f. Gynaek., 1937, 61: 27.
4. Hinselman. Veit's Handbuch der Gynaekologie—Stoeckel. Vol. 6, part 1, p. 874. Munich: J. F. Bergmann, 1930.
5. Hyams. Am. J. Obst. & Gynec., 1933, 5: 653.
6. Kermauner. Biologie und Pathologie des Weibes—Halban and Seitz. Vol. 4, p. 69. Berlin: Urban & Schwarzenberg, 1928.
7. Meyer, R. Handb. d. spez. path. Anatomie u. Histologie, 1930, 7: 165.
8. Overholser and Allen. Proc. Soc. Exper. Biol. & Med., 1933, 30: 1322.
9. Ribbert. Lehrbuch d. Pathologie u. Histologie. Bonn, 1896.
10. Stahler. Arch. f. Gynaek., 1933, 153: 561.
11. Selye, Thompson, and Collip. Nature, 1935, 135: 65.
12. Wollner. Surg., Gynec. & Obst., 1937, 64: 758.
13. Idem. Am. J. Gynec. & Obst., 1938, 36: 10.

EARLY PHASES OF PROSTATIC HYPERPLASIA

CLYDE L. DEMING, B.A., M.D., F.A.C.S., and CHARLES NEUMANN, M.D.,
New Haven, Connecticut

MANY theories have been proposed by men interested in the various branches of medicine to explain the development of benign prostatic enlargement in man. An extensive study of the gross and microscopic lesions has been made, but insufficient attention has been given to the early phases of the enlargement. The urologist frequently observes that the benign enlargement of the prostatic gland, which he sees at operation, is covered by a thin layer of posterior urethral epithelium. In many instances, the tumor seems to replace most of the prostatic gland. There is full agreement with regard to the histological constituents of the surgical specimens. They are composed of glandular, fibrous, and muscular tissues, but the relative amounts of these tissues are variable. The fact that there is a preponderance of the glandular tissue has led investigators to presuppose that the enlargements are mainly glandular in origin. The wide distribution of the glandular nodules in the various lobes of the prostate is further evidence in support of this theory. One of the outstanding declamations is that of Marion and Zuckerkandl, who believed that these enlargements begin in the glands of Albarran. Velpeau, as early as 1841, recognized fibromuscular masses. Thompson, in 1873, was inclined to believe that the primary tumors bear some resemblance to early uterine myomas. As late as 1929, Kausch, in Germany, suggested that the glandular elements are derived from the deep urethral glands. Keyes, Hinman, and Randall adduce evidence from the material studied to show that most of the foregoing theories of early development of "prostatic hypertrophy" are justifiable.

It is necessary to have more definite knowledge concerning the early anatomical phases of benign prostatic enlargement before its cause can be logically established. It is the object of this paper to attempt to throw more light on the first and foremost part of the problem, namely, the beginnings of the so called prostatic hypertrophy. In the prostatic glands which we see at the operating table, so much disorientation of the components of the organ has been produced by growth, pressure, and atrophy that little information is to be obtained from a study of them. The basis for consideration of the early anatomical lesions of the so called prostatic hypertrophy is the study of anatomical specimens of prostates obtained at autopsy from subjects 45 years of age and upward. From the microscopic study of minute, early lesions one can hope to show where and how the lesion originates.

The specimens were fixed in 10 per cent formalin solution and cut transversely at five different levels. When small nodules were discovered, either with the naked eye or by microscopic study, serial sections were cut of the entire transverse section involved, and the nodule or nodules were followed up and down the prostate to their terminations. Various stains were used, but the hematoxylin-eosin and Masson trichrome stains have proved the most satisfactory, the latter being employed to differentiate muscle from fibrous tissue. The large and complete sections were first studied by throwing the entire section on the screen with the projectoscope. This gave an opportunity for comprehensive study of the architecture of the gland as a whole which it is impossible to obtain by the use of the microscope. For minute, localized detail of the sections, the microscope played its part.

From 150 specimens, 24 prostates with sufficiently early lesions have been studied. The specimens contain aglandular and glandular areas in various stages of development. In most of the specimens the two lesions exist together; in 6 only aglandular masses are found; in none of the specimens do glandular nodules exist without aglandular areas.

From the Departments of Surgery and Pathology, New Haven Hospital, and Yale University.

Read at the annual meeting of the American Association of Genito-Urinary Surgeons, Absecon, New Jersey, May 2–4, 1938.

Fig. 1. Photomicrograph of prostate of man aged 72 years. Section near verumontanum, showing fibromuscular nodule near urethra. ×2.

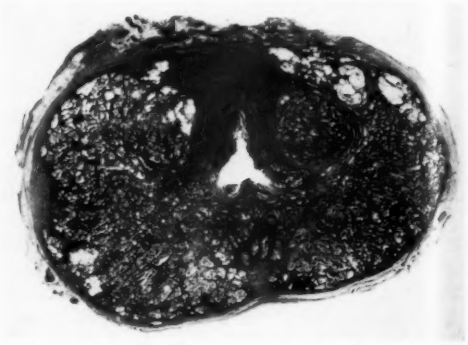


Fig. 2. Photomicrograph of prostate of man aged 68 years, showing glandular nodule in lateral portion of muscular urethral wall. Glandular nodule in lateral portion of muscular urethral wall. Glandular nodule contains heavy muscular stroma. ×1½.

The aglandular areas are found within the musculature of the urethral wall. They may be single (Fig. 1) but are more often multiple and bilateral, located anywhere within the musculature of the urethral wall between the external and internal sphincters. As they develop in size, they tend to become round and oblong in shape and may later become quite large and encapsulated. As the result of localized outgrowths or of the union of two or more of the developing centers, they may assume a nodular appearance. That these aglandular nodules develop to a size sufficient to cause urinary obstruction has been well demonstrated by Hinman and Sullivan, Mitchell and Blaisdell, and Veseen. In the routine histological examination of surgical prostatic specimens, it is not uncommon to find masses of solid tissue and even definite encapsulated aglandular nodules in the presence of glandular nodules. Patch and Rhea found that 25.4 per cent of 181 consecutive surgical specimens of so called prostatic hypertrophy showed leiomyomatous nodules varying in size from 0.5 to 3.0 millimeters.

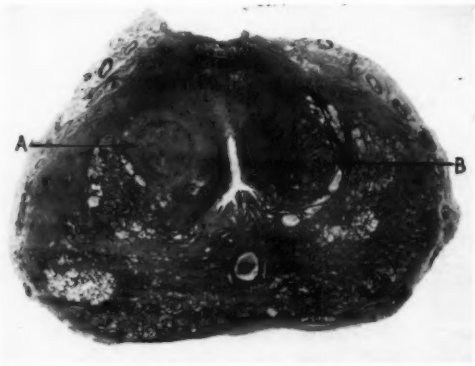


Fig. 3. Photomicrograph of prostate of man aged 74 years, showing bilateral tumors. *A*, a fibromuscular nodule half invaded by glands. *B*, a small glandular nodule on opposite side. ×1½.

The glandular nodules vary in size and are surrounded by circular muscle fibers (Fig. 2). The acini within a nodule may show active budding projections and dilated cystic areas. Cystic dilatations may appear early, but corpora amylacea are not seen in the early lesions. The glandular nodules are found in the muscular wall of the urethra (Fig. 3) and have not been seen in the lateral and posterior lobes. When these nodules increase in size, they deflect the urethra greatly, compress the true lateral and posterior lobes, and appear as lateral lobes on either side of the urethra. They apparently do not develop from the suburethral glands of Albarran, as was formerly thought.

The study of serial sections has led the authors to believe that the glandular nodules are a result of the invasion of an aglandular nodule by epithelial buds from an adjacent

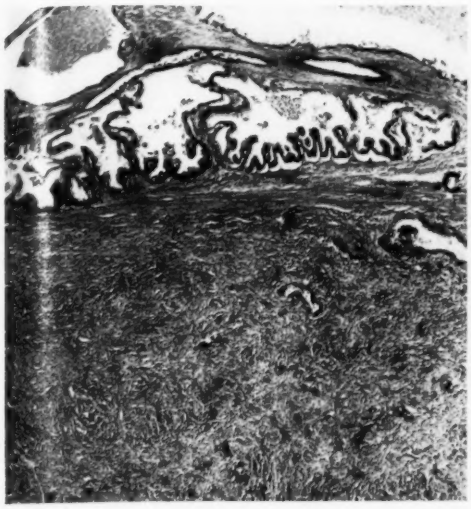


Fig. 4. Photomicrograph of prostate. Fibromuscular nodule with budding duct branches adjacent to the nodule but external to capsule, *C*. Note epithelial proliferation on duct wall adjacent to nodule and relative inactivity on its opposite wall. ×42½.

Fig. 5. Same as Figure 4, 100 microns distant.

duct. These epithelial buds may enter the solid nodule laterally or centripetally and form glands. Because the glands grow more rapidly than the muscle and collagenous tissue, they may entirely replace the muscle tissue and cause the nodule to appear wholly glandular. As the peripheral muscle tissue becomes compressed, it forms the "surgical capsule" of the glandular mass. This method of glandular tissue formation from ducts is similar to that seen in the normal embryological budding from the posterior urethra, which forms the anlage of the prostatic glands. This process may be a re-awakening of the activity possessed by these ducts during the embryological period. One can readily demonstrate this epithelial response on the inside of a duct adjacent to an aglandular nodule, while directly across its lumen the epithelium is dormant (Figs. 4 and 5).

In this study, glandular nodules have not been found in the lateral and posterior lobes of the prostate. Aglandular nodules have been seen in the roof of the urethra and below the crista urethralis, from which hyperplastic lobes could theoretically develop. The anterior and middle hyperplastic lobes have not been studied, nor have we found the reason for the occurrence of an isolated glandular lobule within the bladder at some distance from the prostate and not connected with it. A continuation of these studies should undoubtedly reveal these mysteries.

Since the glandular component of the prostatic hyperplasia is seen to be derived from the prostatic ducts within the urethral muscular wall, one would like to analyze further the origin of the aglandular nodules. The fibromuscular nodules of the prostate resemble histologically the fibromyomas of the uterus (Fig. 6). The uterine tumor has been shown to develop from a muscle cell. The sinus utricularis is the homologue of the uterus and hence of muellerian duct origin. The work of Lowsley, Walker, and others on the embryology of the prostate and urethra discloses the fact that the muscle fibers of the lower muellerian duct system meet the muscle fibers of the wolffian duct system in the posterior urethra and intertwine themselves with the muscles which come down from the ureters, trigone, and bladder. The largest number of solid muscular nodules is found near the utricle and below its floor (Fig. 7). The aglandular, fibromuscular tumors

Fig. 6. Photomicrograph of prostate of man aged 67 years, showing fibromyomatous nodule. Note capsule. Few glands in one side and definite whirl of muscle fibers resembling uterine myoma. ×40.

develop around small blood vessels which increase in number with the growth and nourish it (Fig. 8). Whether the nodule remains fibromuscular or is transformed into a glandular

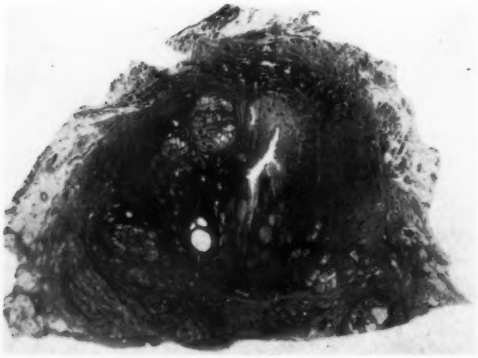


Fig. 7. Photomicrograph of prostate of man aged 64 years. Note small light areas below floor of urethra representing early fibromuscular nodules. Three glandular nodules are also present. ×2.03.

Fig. 8. Photomicrograph of prostate. Early fibromyomatous nodule forming around vessels. ×41.

nodule depends on whether or not the primary nodule is invaded by the epithelium of an adjacent duct.

Further evidence to support the hypothesis that these tumors of the prostate arise from the vestigial component of the muellerian system may be elicited from a consideration of activity produced in homologous vestigial organs by hormones. In the dog, all the prostatic glands are derived from the epithelium of the utricle, which is very sensitive to estrin (Zuckerman). In rodents and the rhesus monkey, part of the glands of the prostate take their origin from the urethral buds and part from the sinus epithelium, while in man all of the prostatic glands have been shown to originate from urethral epithelial buds. Further study along this line should add materially to the practical issues involved in tissue reactions to hormones.

Our present knowledge of these specific reactions, although limited, is supported by Lower and his co-workers, who have produced a physiological hypertrophy of the prostate

in dogs and rats. As far as the authors are aware, no one has ever demonstrated a pathological benign prostatic enlargement in dog, rodent, monkey, or horse which caused retention of urine, nor has such a lesion been produced experimentally in animals. All of the experimentally produced prostatic enlargements are physiological hypertrophies, not tumors or hyperplasias. We must not confuse them with the pathological lesion in man. The natural prostatic enlargement in the old dog compares histologically with the experimental enlargement produced by testicular hormonal injections. It can be reduced by removal of the testicular hormone or by castration of the dog. Castration in man has failed to show any effect on the pathological prostatic enlargement. The fact that benign pathological enlargement of the prostate has been found in eunuchs leads one to minimize the part played by the testicle in its development.

Rothschild, Greene, and Brooks believed prostatic enlargement to be the result of inflammation, as suggested by Ciechanowski; but Cabot and Smith have clearly demonstrated that men with histories of infection are less likely to develop a "prostatic hypertrophy." Prostatic enlargement is not due to arteriosclerotic changes, because it occurs in individuals who do not have arteriosclerosis. Reischauer's theory of compensatory hypertrophy is illogical. Kausch has correctly ruled out the adenoma theory, because the growth does not fulfill the criteria enunciated for adenomas. We have shown that the enlargement does not begin in glands, nor is it necessarily derived from glands. If it were derived from the musculature around a duct or gland, the primary nodule would show a duct or gland within its center. This has not been shown in our observations.

SUMMARY

This work definitely discloses that the early change of benign enlargement of the prostate in man is primarily a multiplication of fibromuscular elements. It resembles in its early stages the uterine fibromyoma, which is derived from a muscle cell of the uterus. Since the posterior urethra and the internal vesical sphincter contain muscle fibers which are derived from the same embryological building material as that of the uterus, it is fair to assume that these two tumors have the same origin. We do not agree wholly with Adrion that the glandular portion of the tumor is necessarily derived from glands but believe that it has its origin in ducts adjacent to the fibromyomatous nodule. The suburethral glands of Albarran are not involved in early lesions. It is probable that the solid nodule produces some stimulating and proliferating effect upon the epithelium of the duct wall, causing the epithelium to invade the solid nodule and form glands within it. The fibromyomatous tissue is invaded and overgrown by a more rapidly growing duct and glandular tissue, with the result that the nodule in its later stages develops the appearance of an encapsulated glandular tumor. Benign prostatic enlargements are not hypertrophies but are true hyperplasias, derived from muscle, fibrous tissue, and ducts.

Recognition is made of the assistance of Dr. Dan S. Egbert and of Dr. Hyman A. Weiner in the early part of this study. Appreciation is also expressed to Mrs. Ethel Kober for the preparation and mounting of the histological sections.

The greater part of this work was made possible by an anonymous gift and by a grant from the Fluid Research Fund of Yale University.

REFERENCES

1. Adrion, Walter. Ein Beitrag zur Aetiologie der Prostatahypertrophie. Beitr. z. path. Anat. u. z. allg. Path., 1922, 70: 179-202.
2. Cabot, Hugh, and Smith, George G. The influence of stricture of the urethra on the development of hypertrophic changes in the prostate. Lancet-Clinic, 1912, 107: 456-465.
3. Ciechanowski, S. Anatomische Untersuchungen ueber die sogennante Prostatahypertrophie und verwandte Prozesse. Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1901, 7: 183–332.
4. Greene, R. H., and Brooks, H. The nature of prostatic hypertrophy. J. Am. M. Ass., 1902, 35: 1051–1059.
5. Hinman, Frank. The Principles and Practice of Urology. Philadelphia: W. B. Saunders Co., 1935.
6. Hinman, Frank, and Sullivan, John H. Two cases of leiomyoma of the prostate. J. Urol., 1931, 26: 475.
7. Hirsch, E. W. Pathology of prostatic hypertrophy. J. Urol., 1936, 35: 227–234.
8. Kausch, H. Die Prostatahypertrophie. Frankfurt. Ztschr. f. Path., 1929, 38: 333–361.
9. Keyes, Edward L., and Ferguson, Russell S. Urology. 6th ed. New York: D. Appleton-Century Co. 1936.
10. Lower, W. E. Endocrine influence on male sex organs. New England J. Med., 1933, 208: 878–886.

11. Idem. The prostatic problem. J. Urol., 1937, 37: 555–556.
12. Lower, W. E., Engel, W. J., and McCullagh, D. R. Summary of experimental research on control of benign prostatic hypertrophy and preliminary clinical report. J. Urol., 1935, 34: 670–677.
13. Lower, W. E., and Hicken, N. F. Experimental research by parabiosis showing hypophyseal-gonadal influence on growth and development of prostate gland. J. Urol., 1932, 28: 601–606.
14. Lowsley, Oswald S. The development of the human prostate gland with reference to the development of other structures at the neck of the urinary bladder. Am. J. Anat., 1912, 13: 299–349.
15. Marion, G. Hypertrophie de la Prostate. Encycl. franç. d'urol., Vol. 6. Librairie Octave Doin, 1923.
16. Mitchell, D. R., and Blaisdell, J. L. Leiomyoma of the prostate. Brit. J. Urol., 1933, 5: 381.
17. Patch, F. S., and Rhea, L. J. Leiomyoma of the prostate gland. Brit. J. Urol., 1935, 7: 213–228.
18. Randall, A. Surgical Pathology of Prostatic Obstructions. Baltimore: Williams & Wilkins Co., 1931.
19. Reischauer, F. Ueber die formale Genese der sogenannte Prostatahypertrophie. Beitr. z. klin. Chir., 1934, 160: 460–483.
20. Rothschild, A. Ueber die Frage der aetiologischen Beziehungen zwischen Gonorrhoe und Prostatahypertrophie. Centralbl. f. d. Krankh. d. Harn-u. Sex.-Org., 1904, 15: 177–190.
21. Tandler, J., and Zuckerkandl, O. Studien zur Anatomie und Klinik der Prostatahypertrophie. Berlin: Julius Springer, 1922.
22. Thompson, H. The Diseases of the Prostate: Their Pathology and Treatment, Comprising the Jacksonian Prize Essay for the Year 1860. 4th ed. Philadelphia: H. C. Lea, 1873.
23. Velpeau. Leçons Orales de Clin. Chir., Paris, 1841, 3: 478. Cited by Crandon, L. R. G. The pathogenesis and pathological anatomy of enlarged prostate. Ann. Surg., 1902, 36: 846.
24. Veseen, L. L. Fibromuscular hyperplasia of the prostate. J. Urol., 1929, 22: 302.
25. Walker, George. A contribution to the study of the anatomy and physiology of the prostate gland, and a few observations on the phenomenon of ejaculation. Johns Hopkins Hosp. Bull., 1900, No. 115: 242–256.
26. Zuckerman, S., and Groome, J. R. The ætiology of benign enlargement of the prostate in the dog. J. Pathol. & Bacteriol., 1937, 44: 113–124.

THE ANATOMY OF THE PELVIC AND UROGENITAL DIAPHRAGMS, IN RELATION TO URETHROCELE AND CYSTOCELE

ARTHUR H. CURTIS, M.D., F.A.C.S., BARRY J. ANSON, Ph.D. (Med. Sc.), and CHESTER B. McVAY, M.S., M.D., Chicago, Illinois

IN the course of a re-study of the female pelvis and perineum, certain controversial anatomical features of gynecological importance remained undetermined after our concerted attack from the combined viewpoints of the anatomist and the gynecologist, despite painstaking dissection of the pelves of five selected female bodies; a sixth dissection, this time from within the pelvis, displayed the anatomical relationships so effectively that we are impelled to present our observations and clinical deductions.[1] The three accompanying illustrations by Tom Jones are life-size[2] drawings made from the actual dissections.

PERITONEUM AND EXTRAPERITONEAL (CELLULAR) TISSUE

Within the pelvis of the present specimen, and in the manner regularly described, the parietal peritoneum of the abdominal cavity proper is carried downward into the pelvic subdivision of the cavity, where it is draped over the contained viscera, adapting itself to the inequalities produced by them.[3] This peritoneum is at an appreciably higher level than the parietal fascia which covers the pelvic floor (the superior fascia of the pelvic diaphragm). There is thus created a considerable subserous space between the peritoneum and the fascia; this is filled with an adipose areolar tissue, through which course the visceral nerves and vessels.[4]

The features of anatomy described are corroborative of those found in the usual descriptions of the female pelvis. With them the present study is not particularly concerned, our interest being centered in the diaphragmatic structures upon which the pelvic organs rest, and their tubular reflections, which, ascending upon the organs, form strong musculofibrous investments.

ENDOPELVIC FASCIA

A firm fascia covers the pelvic floor; this is the superior fascia of the pelvic diaphragm (Fig. 1); the endopelvic fascia is that portion which is reflected from the floor upward upon the viscera. The manner of reflection for the bladder is different from that for the rectum and vagina (Fig. 1). An aponeuroticofascial ridge sweeps forward from the region of the spine of the ischium, and soon divides into an inferior fascial arch, the white line, and the somewhat more superiorly placed, slightly curved arcuate ligament. At the lateral wall of the bladder the fascial arch (the white line) is a wing-like elevation standing away from the pelvic wall; the abundant cellular tissue is easily removable from it. Each wing divides to pass in front of and behind the bladder, thus forming a fascial tube for that organ. The urethra is covered anteriorly with the endopelvic fascia; but laterally, the fascia is stretched from the pelvic wall to the bladder above the level of the urethra.

The fascial tubes of the endopelvic fascia for the vagina and the rectum are reflected

From the Department of Obstetrics and Gynecology and the Department of Anatomy (contribution no. 277), Northwestern University Medical School. Presented, in part, at the San Francisco meeting of the American Medical Association (J. Am. M. Ass., 1938, 111: 903).

[1]The subject was a negress, 20 years of age, 5 feet 3 inches tall, weight 72 pounds (after embalming). The pelvis and perineum were completely free from gross pathology; the arteries were unusually well injected. It is the authors' belief that such a report upon serial dissections of a completely normal subject should be helpful to the gynecologist; stylized portrayals are common, conventionalized descriptions thereof equally abundant. It is planned to extend this study as rapidly as suitable specimens become available.

[2]The plates have been reduced to five-eighths actual size.

[3]Compare Figs. 86 to 89, 94 to 96, in Anson, B. J., Anatomy of the female genitalia and pelvic soft parts, Chapter I, and Obstetrics and Gynecology, edited by Arthur H. Curtis, Philadelphia: W. B. Saunders Co., 1933.

[4]Figs. 12 and 13, in Curtis' Textbook of Gynecology, 3d ed. Philadelphia: W. B. Saunders Co., 1938.

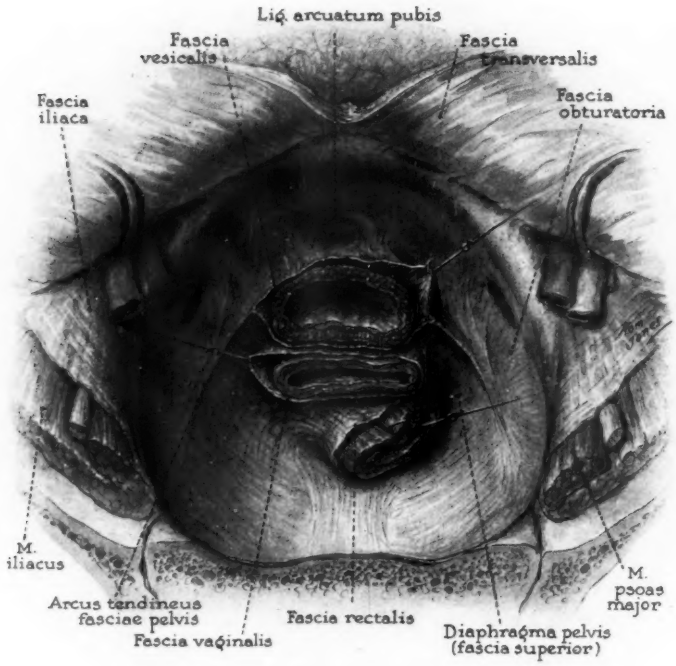


Fig. 1. Anterolaterally, the layers of the abdominal wall have been turned forward along a medial cut; posterolaterally, the alæ of the ilium have been cut horizontally, together with the iliopsoas muscles and fasciæ; posteriorly, the sacrum has been transected at the same horizontal level. All of the peritoneum and the subserous tissue have been removed to expose the fascia of the pelvis. Within the lesser pelvis, the organs have been transected, together with reflections of the diaphragmatic fascia, the endopelvic fascia. The vesical, vaginal, and rectal tubes of endopelvic fascia have been freed from their respective viscera and retracted.

upward from the pelvic floor at the point where these viscera perforate the pelvic diaphragm. In consideration of the fact that there are three tubes of fascia encasing respectively the urethra and bladder, the vagina, and the rectum, it is evident that there is a double layer of fascia between adjacent organs. Each fascial envelope is in intimate relationship with the musculature of the corresponding viscus, receiving muscle fibers from it. And it is the fascial envelopes plus the muscle fibers interwoven with them that are used in the repair of cystocele and urethrocele. Similarly, the rectal and vaginal envelopes together furnish the firm musculofascial support utilized in the repair of the rectocele.

THE PELVIC DIAPHRAGM

Levator ani. As regularly described, the levator ani muscle consists of two subdivisions, pubococcygeal and iliococcygeal.

1. *Pubococcygeus.* The pubococcygeal part of the entire muscle originates along the pubic bone and tendinous arch (Figs. 2 and 3).[1] The

[1]For those readers who may be interested in the actual dimensions of structures herein described, the following records are submitted in this and succeeding footnotes:

The origin of the pubococcygeus muscle along the pubic bone and tendinous arch measures 4.5 centimeters, of which distance 3.2 centimeters is the bony origin, 1.3 centimeters the tendinous origin; the anterior attachment is removed from the obturator canal by a distance of 0.7 centimeter; that portion of the muscle which passes to the vagina is 1.1 centimeter wide, while that which inserts into the rectum has a width of 1.5 centimeters (these measured at their visceral extremities); of that part of the whole muscle which inserts chiefly into the coccyx, a band 1.0 centimeter wide passes to the deeper aspect of the rectum, while the true coccygeal segment is 2.0 centimeters wide; the ligamentous band which covers the insertion of the hinder part of the pubococcygeus was originally 1.7 centimeters wide, but has been cut to one-half that width as illustrated in Fig. 2. The connection between the urethra and the vagina is a strong one, the strength of the attachment owing to the presence of those muscle fibers which cross between the two tubes.

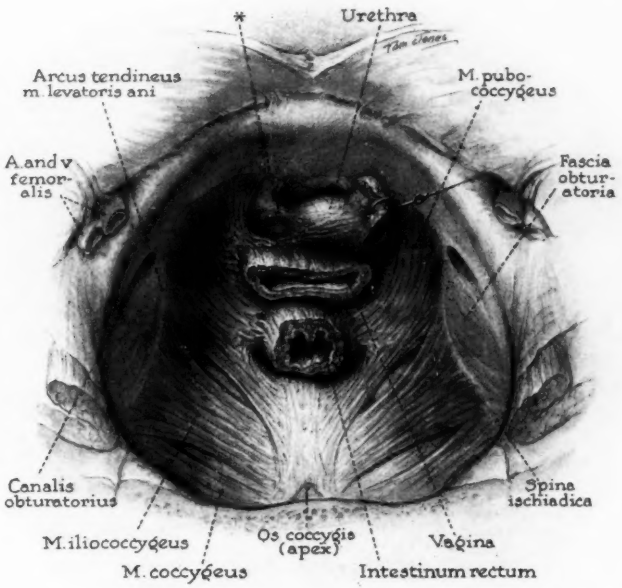


Fig. 2. The fascial layers illustrated in Figure 1 have been removed and the viscera excised to a lower level, in order to demonstrate the muscular constituents of the pelvic floor and the relations of these to the viscera. The urethra has been pulled aside to show the course of the levator fibers on its posterior aspect and the nature of the "pubourethral ligament," indicated by an asterisk.

upper border is arching, convex on its superior edge, this line of attachment coinciding at the summit of the convexity with the edge of the obturator foramen at the position of the obturator canal.

This anterior portion of the levator ani inserts not only into the coccyx but also into the urethra, the vagina, and the rectum; the rectal portion is broadest; the vaginal insertion is two-thirds as wide as the rectal, and but few fibers enter the urethra, these upon its posterolateral aspect.

The fibers of the muscle which pass to the vagina ascend for a short distance upon the vagina, then lose themselves in the intrinsic musculature of the organ.

These important visceral relations of the pubococcygeal muscle are neglected features in the textbooks of anatomy which students and practitioners customarily consult; no mention has heretofore been made of the relations of the muscle bundles to the urethra; that which has been offered regarding their relation to the vagina and the rectum is incorrect.

Thus, Gray (1936) states that the pubococcygeus is directed backward along the side of the anal canal on the way to a coccygeal attachment; according to Cunningham (1937) the medial part of this muscle (termed puborectalis) sweeps backward over the side of the vagina and the rectum, the muscles of the two sides meeting dorsally to form a sling for the anorectal junction. This concept is repeated in Morris (1933), the statement being made that the fiber bundles course past the urogenital organs and the rectum on each side. According to Spalteholz (1930) a few fibers are sent into the wall of the rectum; Piersol (1930) similarly describes an insertion of pubococcygeal fibers into the lower part of the rectum.

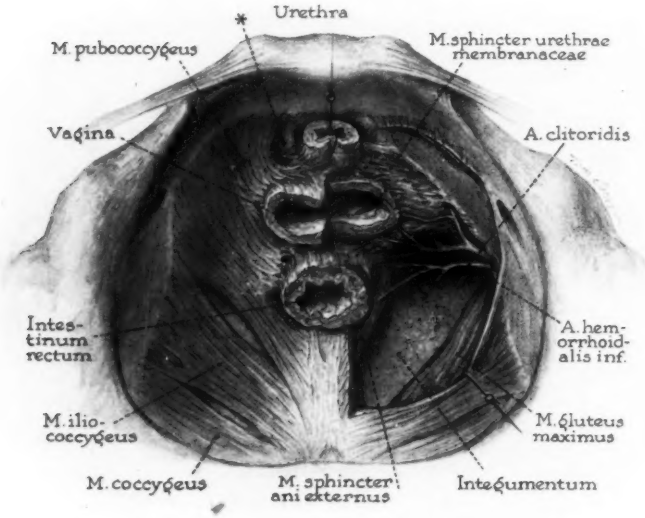


Fig. 3. The musculature of the left side remains the same as in Figure 2. The urethra has been cut down to within 1.4 centimeters of the urogenital diaphragm. The right half of the vagina has been cut to a level corresponding to that of the superior surface of the urogenital diaphragm; on the left it remains as in the preceding figure. On the right the pubococcygeal portion of the pelvic diaphragm has been removed and the iliococcygeal portion has been retracted to show the gluteus maximus muscle. From the ischiorectal fossa all of the fatty tissue has been removed to expose the inner surface of the perineal integument. The musculature of the urogenital diaphragm (the urethral sphincter) is revealed by the removal of the superior fascia; additionally, the pudendal artery and its branches are shown as they pass from Alcock's canal to the viscera and urogenital diaphragm; the veins have been excised.

It is evident from the foregoing that no standard work on anatomy presents a description of pelvic structure which meets the requirements of present day gynecology.

As in the case with the vaginal part, the muscle fibers of the rectal subdivision of the pubococcygeus are lost in the intrinsic coat; the small muscle bundles became tendinous and insinuate themselves into the space between the longitudinal and circular coats of intrinsic musculature, there interdigitating with the fibers of smooth muscle. Between these interdigitating muscle bundles there occur definite hiatuses through which pass small hemorrhoidal vessels; with the unaided eye at least five of these can be seen (vessels have been removed in the dissections so that only spaces are seen in Figs. 2 and 3).

The part of the entire pubococcygeus which inserts chiefly into the coccyx resembles a true subdivision, since between it and that portion which terminates in the rectal wall a cleft exists along two-thirds the length of the adjacent margin—the cleft interrupted midway by an exchange of muscle fibers across the hiatus. The cleft is prominent at its medial end, since there it is bounded posteriorly by fibers which pass to a deeper part of the rectum. The insertion of the hinder part is covered by a ligamentous band which takes the place of the expected rectococcygeus muscle.

2. *Iliococcygeus.* This posterior or iliac part of the levator ani at its origin is chiefly tendinous (Figs. 2 and 3).[1] The border is concave superiorly, the combined origin of the iliococcygeus and pubococcygeus describing an S-shaped curve. At the extreme posterior por-

[1]The iliococcygeus muscle is 3.3 centimeters wide at its origin, 1.5 centimeters at its coccygeal insertion (of which approximately 0.8 centimeter is overlapped by the pubococcygeus).

tion of the band the muscle arises from the spine of the ischium; but as far as can be determined by palpation only the three or four posterior fascicles actually arise from the bone. The band as a whole can be readily separated almost throughout its length from the adjacent margin of the coccygeus muscle. Its insertion is entirely bony; no fibers enter the walls of the pelvic organs.

3. *Coccygeus* (Figs. 2 and 3). The plane of the flat surface of the coccygeus lies at almost right angles to that of the iliococcygeus.[1] In the region of the ischial spine the separate fascicles are very evident, but medially the surface is smooth and tendinous rather than muscular. The muscle at its coccygeal insertion is excessively thin. It is aponeurotic at its insertion, and almost entirely aponeurotic along its posterior margin.

THE UROGENITAL DIAPHRAGM

The superior fascia of the urogenital diaphragm, in relation to the urethra, is not a smooth plane, being elevated at the lateral margins of the urethra to a height of 0.8 centimeter above the floor proper (Fig. 2). This paired structure is a miniature counterpart of the uterosacral ligaments. Arising from the pubic bone it forms bilateral bands which narrow somewhat, then spread out upon reaching the urethral wall. Posteriorly, in ascending from the pelvic floor, they are smooth; but anteriorly they are set off from the pelvic floor and elevated in the form of wing-like margins. Together the wings, which might well be called *pubo-urethral ligaments*, bound a tiny cul-de-sac through which the perineal veins communicate with the pelvic venous plexus (removed in the dissections); this cul-de-sac, oval in outline, is 1.5 centimeters wide, 0.8 centimeter long (with the urethra retracted posteriorly). These ligamentous wings correspond in position to the transverse ligament of the pelvis but they are more than simply the fused fascial layers of the urogenital diaphragm, since within each is included a band of muscle fibers. They ascend on the lateral walls of the urethra for a distance of 0.6 cm., the skeletal fibers becoming lost among those of its intrinsic musculature (Fig. 3).[2] Here, again, as in the relationships of the levator to the organs, current descriptions have been found to be inadequate.

The urogenital diaphragm (triangular ligament) as a whole, situated below and in front of the pelvic diaphragm, completes the pelvic support; arising from the inferior ischiopubic rami, this musculomembranous shelf stretches across the anterior one third of the pelvic outlet at a right angle to the long axis of the vaginal canal. The muscles of the urogenital diaphragm constitute the external sphincter of the urethra in the male; but in the female they are also closely related to the vagina and the urethra. The muscle fibers course chiefly in a transverse direction, toward the midline. Encountering the tubular organs, they insert firmly into their walls (Fig. 3).

As described, bilateral bands of muscle bundles ascend, wing-like, upon the urethra, clothed by the superior fascial layer of the diaphragm. Between the urethra and the vagina only a slight interval exists, through which a few fibers of the sphincter interdigitate with those from the opposite side of the perineum. The bulk of the muscle fibers of the so called sphincter of the urethra actually terminates in the wall of the vagina, as does the musculature of the levator ani. The space between the vagina and the rectum is again so narrow that fibers can scarcely be traced across the midline at that point. The most posteriorly placed muscle fibers of the urogenital diaphragm do not terminate as muscle fascicles in the wall of the rectum; rather it would seem that there are aponeurotic extensions to the rectum of those muscle fibers

[1] The coccygeus muscle is 2.4 centimeters wide at its origin, 4.0 centimeters in width at the insertion; at this extremity the aponeurosis attaching the muscle to coccyx is exceedingly thin, measuring slightly less than 0.1 centimeter in thickness. Since the only important difference structurally between the iliococcygeus and the coccygeus is in the character of the origin, the present terminology would seem to be illogical. While one muscle arises principally from tendon and the other from bone, both insert into the coccyx or coccyx and sacrum. It would seem that the former should be termed iliococcygeus, as it now is (since its tendinous origin is iliac), whereas the latter should be called ischiococcygeus, because its insertion sets it off from the other two portions; it really should be included with them as one of the constituents of the pelvic diaphragm. The fact that the coccyx is wide proximally and therefore fills a greater portion of the pelvic opening should make no difference in the scheme of naming these two muscles. So far as can be judged from the specimen, the origin of the coccygeus takes place from the very margin of the ischium just above the spine and from the posterior border of the spine itself.

[2] That part of the urethral sphincter muscle which ends in the vagina is 1.3 centimeters wide; that which terminates in the urethra is exactly half that width. The pelvic urethra, which would correspond to the prostatic portion of the male, is 2.5 centimeters in length. The urethra measures 1.4 centimeters in the transverse direction, 0.8 centimeter in the sagittal. It is apparent from probing its lumen that an appreciable dilatation occurs between the internal meatus and the level of the urogenital diaphragm.

which are contributed to the perineal body. They affect only the anterior third of the rectal wall; the remaining posterior two-thirds of the rectum receives fibers only from the pelvic diaphragm.

ISCHIORECTAL FOSSA

Just inferior to the line of attachment of the combined origin of the pubococcygeal portion of the levator ani muscle, and superior to the bony origin of the urogenital diaphragm next below, is situated the obturator fascia, as it forms the lateral wall of the anterior recess of the ischiorectal fossa (Fig. 3). Medially, near the viscera, this recess is a mere chink along the line of fusion of the muscles and investing fascias of the urogenital and pelvic diaphragms. Its roof is the pubococcygeal portion of the levator ani (retracted in Fig. 3 to reveal the posterior recess of the same fossa). Its floor is the gluteus maximus muscle. Crossing this space are the vessels which will be described hereinafter. At the medial limit of the fossa is the external sphincter muscle of the anus.[1]

At the anterior limit of both diaphragms their layers virtually meet, the cleft between the levator ani and the subjacent superior fascia of the urogenital diaphragm being a very slight one.[2] It will be recalled that at this anterior point the urogenital diaphragm is elevated locally to form bands which we have chosen to name the "pubo-urethral ligaments."

BLOOD VESSELS

Arteries. From the internal pudendal artery two vessels are given off; the posterior one to structures in the anal triangle, the anterior to those in the urogenital (Fig. 3). The posterior stem is the inferior hemorrhoidal artery which sends branches to the anal canal and, enroute, several to the fatty tissue in the fossa. The anterior stem divides into two branches; from the hinder one of the two, twigs are given off to the musculature in the two compartments; one twig, the perineal artery, pierces the base of the superficial compartment. The forward branch, like the others, courses anteriorly, remaining near the lateral wall of the anterior recess in the substance of the urogenital diaphragm; therein it gives off muscular branches and sends twigs to the vagina.[3] The main stem continues forward as the clitoridal artery. *Veins.* The veins in general follow, in plexiform manner, the arterial stems.

LITERATURE CITED

1. Anson, B. J. Anatomy of the female genitalia, etc. Chapter I. Obstetrics and Gynecology. Edited by Arthur H. Curtis. Philadelphia: W. B. Saunders Co., 1933.
2. Cunningham's Text-book of Anatomy. Edited by J. C. Brash and E. B. Jamieson. 7th ed. New York: Oxford University Press, 1937.
3. Curtis, A. H. Textbook of Gynecology. 3d ed. Philadelphia: W. B. Saunders Co., 1938.
4. Gray, Henry. Anatomy of the Human Body. Edited by W. H. Lewis. 23d ed. Philadelphia: Lea & Febiger, 1936.
5. Morris' Human Anatomy. Edited by C. M. Jackson. 9th ed. Philadelphia: P. Blakiston's Son & Co., 1933.
6. Piersol's Human Anatomy. Revised by G. C. Huber. 9th ed. Philadelphia: J. B. Lippincott Co., 1930.
7. Spalteholz, W. Hand-Atlas of Human Anatomy. Edited by L. F. Barker. 3d Eng. ed. Philadelphia: J. B. Lippincott Co.

[1]The vertical depth of the external anal sphincter is 1.3 centimeters.

[2]While anteriorly the two diaphragms, pelvic and urogenital, are in contact, posteriorly—at the hinder limit of the urogenital—the two are separated by a distance of 4.0 centimeters, measured along the lateral wall of the ischiorectal fossa; this corresponds to the posterior limit of the pubococcygeus muscle. Laterally, a distance of 7.0 centimeters intervenes between the line of origin of the muscle and the inferior margin of the ischial tuberosity. The urogenital diaphragm is 3.0 centimeters in length (measured in parasagittal plane in a line just lateral to the urethra). In the transverse direction from obturator fascia to midline, the distance is 1.5 centimeters, measured at the anterior margin of the urethra. At the posterior margin of the urethra, the corresponding measurement is 2.2 centimeters (this line would pass through the cleft between urethra and vagina). At its posterior margin, the diaphragm, is 4.0 centimeters wide (this line passes between the rectum and vagina). The thickness of the diaphragm posteriorly is 3.0 to 4.0 millimeters (the thickness of the anterior portion of the pelvic diaphragm is 2.5 millimeters; in comparison with this the thickness of the posterior margin of the coccygeus is 1.5 millimeters).

[3]The reader is referred to Fig. 9 in Curtis' Textbook of Gynecology, 3d ed., wherein is shown, from actual dissection, the rich set of vaginal branches of the bulbar artery.

EARLY SURGERY IN BILIARY DISEASE

E. L. ELIASON, B.A., M.D., Sc.D., F.A.C.S., and J. PAUL NORTH, A.B., M.D., F.A.C.S.,
Philadelphia, Pennsylvania

STATISTICS from the large medical clinics in this country show that biliary disease is the most frequent single cause of indigestion, and that 60 per cent of the complaints made to the physician are referred to the gastro-intestinal tract. Expressed differently it can be safely stated that 15 per cent of the population of the United States suffers from biliary disease. This figure increases to 30 per cent after the age of 45 years. In the past the diagnosis was made entirely upon clinical findings and history and consequently many cases were missed until the extracystic complications of jaundice, pancreatitis, cholangitis, etc., showed the true state of affairs. Today, however, there is but little excuse for overlooking biliary disease. Eighty per cent of our own diagnostic failures have been due to inability, through linguistic difficulties, to obtain a satisfactory history. We never operate on dye evidence alone. The use of the x-ray, the dye test, biliary drainage and a careful history should, and has, resulted in earlier and more frequent diagnosis and also in establishing in people's minds the fact that indigestion, gas, dyspepsia, eructations, etc., are merely symptoms of a disease that requires surgery to establish a cure. And yet vital statistics of the insurance companies show that the nation's mortality from this condition is just as high as it was 24 years ago, despite early and better diagnosis and we hope better surgery with vastly improved pre-operative and postoperative care. There is but one answer—and that is delay in the proper surgical treatment while unjustified medical treatment is continued. Medical treatment is rarely, if ever, justified for symptoms producing calculi with or without complications. It is to be remembered that silent gall stones do exist. These rarely if ever require protective surgery but all others do require both protective and corrective surgery. The patient, the physician, and even the surgeon have been all too prone in the past to procrastinate. Surgery practised early in the disease and early in the acute attack has produced a remarkable reduction in morbidity and mortality.

ACUTE CHOLECYSTITIS

At the moment the management of acute cholecystitis is the most controversial topic in connection with the surgery of the gall bladder. Surgeons of outstanding ability are divided in their opinion as to whether it is best to operate on these cases immediately or after the acute attack has subsided. The arguments for immediate operation are that the complications of empyema, gangrene, and perforation occur in acute cholecystitis as they do in acute appendicitis, that these complications frequently are not recognized since the severity of the clinical symptoms does not run parallel to the pathological changes in the gall bladder, that the mortality due to these complications offsets any reduction in mortality which may accrue from delaying the operation, and finally that the patient is spared needless pain. The arguments for delay are that the analogy between acute cholecystitis and acute appendicitis is not valid in that gangrene and perforation are not as likely to occur in the gall bladder as in the appendix, that even if perforation does take place there is a far greater probability of the resulting peritonitis being localized by adhesions, that the gravity of any operation on the gall bladder requires that the general condition of the patient be as favorable as possible, and that the edema of the gall bladder wall during the acute phase makes operation unduly hazardous. In the surgical literature of the past few years the voices of those who favor immediate operation have been raised more loudly than those holding to a conservative viewpoint. This has upset completely the formerly accepted opinion that operation should be withheld until the acute process "cools off." Miller, after having two

patients die from perforation during the period of expectancy, reviewed a series of 200 cases from the Massachusetts General Hospital and observed that in the fatal cases the period from the onset of acute symptoms to operation averaged 15 days, while in those who recovered it was 8.3 days. Zinninger noted that of the patients whose operation was delayed only 37 per cent improved, 35 per cent showed no significant change, and 27 per cent became definitely worse. Stone contends that the tendency to perforation and spreading peritonitis from acute cholecystitis differs only in degree and not in principle from the course of acute appendicitis or perforating ulcer and that the patients who are going to become worse with delay require prompt operation, while those in whom the symptoms would subside do just as well with early surgery. Judd and Phillips noted an incidence of the complications of gangrene and perforation in 13.4 per cent of cases of acute cholecystitis. They subscribe to the plan of early operation with reservations, believing that in certain cases it is wiser to postpone the operation for a long time and that there can be no set plan for dealing with this disease.

Smith, influenced by his experience at St. Luke's Hospital in New York, feels that immediate operation should not be done without urgent indication and, particularly in the older patients and the poor risks, if the course is favorable under observation, it is wiser to wait for "cooling off." Heuer is emphatic about the desirability of early operation pointing out in a review of cases from the New York Hospital that the incidence of extracholecystic abscess in acute cholecystitis is 10.5 per cent as compared with a 17.5 per cent incidence of perforation in acute appendicitis. In Heuer's series, all of whom were operated upon promptly, the operative mortality was only 2.1 per cent unless perforation had occurred prior to operation in which case it was 12.5 per cent. Taylor places the operative mortality at 5 per cent, if operation is done during the first 4 days of the attack, and at 24 per cent thereafter but adds that no case is so urgent that pre-operative administration of adequate amounts of glucose can be neglected.

Confusion has arisen due to the failure of many advocates of early surgery to state clearly

1. Whether immediate operation means an emergency procedure done within an hour or two of the onset of the illness or after the patient's admission to the hospital, or one done after complete studies can be made to assess the patient's condition and the time allowed for the required pre-operative preparations to be carried out;

2. Whether cholecystectomy is done as a routine procedure or the operation adapted to the findings;

3. Whether the incidence of the late complications of biliary fistula and strictures of the ducts following the removal of acutely inflamed edematous gall bladders has increased therefrom.

Preliminary treatment. In cases with a positive or proved diagnosis seen during the first few hours of an attack, morphia hypodermically should be given at once and everything withheld by mouth. Fluids, preferably glucose 5 per cent in salt solution, is given by venoclysis. Operation is undertaken as soon as the necessary general medical survey can be carried out, the frequent co-existence of diabetes and myocarditis with biliary disease being kept in mind. At this stage the absence of edema permits the ideal cholecystectomy to be performed as a rule. Those patients who have been ill 24 to 36 hours without adequate treatment are also best managed by morphine, venoclysis, and starvation for 12 to 18 hours. If after this period any one symptom fails to subside, operation is done. Similarly patients admitted after 24 or more hours, who are still ill despite proper treatment, i.e., morphia and the withholding of everything by mouth, should have prompt operation. It has been our experience that in patients who have had acute obstructive gall-bladder disease for 2 or more days the symptoms will not as a rule subside completely under any treatment except surgery, hence further delay is dangerous and useless. In all three groups the procedure may be either cholecystostomy or cholecystectomy, depending upon the local conditions which govern safe surgery such as induration or edema around the ducts, obscuring the

anatomy, pancreatitis, jaundice, perforation, etc.

When this expectant mode of treatment is adopted and the patient's course is favorable, operation may be deferred until the temperature has been normal at least a week, and the local tenderness has entirely disappeared. Flint points out that usually some pericholecystitis accompanies acute inflammation of the gall bladder and that operation done too soon may result in the spreading of this infection. Furthermore the surgeon is frequently surprised at the amount of residual edema and lymphatic adenopathy found in cases which have apparently subsided. This increases the technical difficulties of the operation and also the hazard of injuring one of the ducts. The pathological state of the gall bladder cannot be safely estimated by any physical or laboratory tests—hence the danger of delay. Not infrequently the problem will arise of persuading a patient to have the operation when he or she seems to have recovered. Such patients are courting certain trouble, and the necessity for operation should be insisted upon.

In determining upon the operation to be done, the crux of this problem lies in the recognition not only of the fact that acute cholecystitis demands early surgical intervention but that the operation must be suited to the conditions of acute local infection. Accordingly the procedure which may be ideal from the standpoint of ultimate morbidity may have to be modified for the sake of immediate mortality. Cholecystectomy is a better operation than cholecystostomy but the latter may frequently be safer and more prudent in the presence of acute inflammation. The rule must be observed absolutely that cholecystectomy should never be done unless the relationships of the hepatic, cystic, and common duct and the cystic artery can be clearly visualized by the surgeon. Granting that in all cases cholecystectomy is more satisfactory from the standpoint of ultimate results, the indications for cholecystostomy may be stated as follows: (1) when the condition of the local tissues militates against safe removal of the gall bladder; (2) when the physical difficulties of obesity, uneven anesthesia, poor illumination or inadequate assistance make proper exposure impossible; (3) when serious local complications, such as jaundice, pancreatitis, or carcinoma call for drainage only; (4) when age or serious renal cardiovascular or pulmonary complications indicate that surgical intervention should be simple and expeditious. The safety of the patient is greatly enhanced if the surgeon will recognize not only his own but the limitations of his patient, and stops with a cholecystostomy rather than attempting too much at one operation.

CHRONIC CHOLECYSTITIS

Surgical treatment is indicated in most cases of chronic cholecystitis with or without stones provided the diagnosis is reached after careful investigation which excludes other possible sources of pain or indigestion. The laboratory findings must not be overemphasized in making this diagnosis unless they are in agreement with the clinical history. The roentgenologic demonstration of gall stones does not necessarily imply that these are responsible for the patient's symptoms, since silent stones are frequently carried for many years. It is for this reason that every effort must be made to exclude extrabiliary causes before subjecting the patient to surgery for failure to do so may result in disappointment to both patient and surgeon. Medical treatment is justifiable so long as it gives uninterrupted relief. There is a tendency in this as in other diseases of a chronic and not completely incapacitating nature to procrastinate before submitting to a major surgical procedure. It must be remembered that not only do the risks and the technical difficulties of biliary surgery increase with delay but after the infection has extended to adjacent organs removal of the gall bladder cannot be expected to cure the patient. Graham aptly illustrates the peril of procrastination by citing operative mortality figures for cholecystectomy. If done after two attacks it is 2 to 3 per cent, after three or more attacks, 8 to 9 per cent, in the presence of jaundice, 10 to 12 per cent, and with pancreatitis it is 50 per cent. Mason estimates that about one third of his patients are relieved by a medical regimen; the others either submit to operation after a few years or should do so but refuse.

The results of surgery in cholelithiasis are better than in non-calculous cholecystitis. This may be due in part at least to the greater accuracy of diagnosis when history of typical colic is elicited. Cholecystectomy likewise gives better results than cholecystostomy. The former is the operation of choice provided the surgeon is able to visualize clearly the relationships of the cystic, hepatic, and common ducts and the cystic artery and provided the condition of the patient warrants the performance of the more extensive operation. There are instances in aged or poor risk individuals when simple removal of stones and drainage of the gall bladder is wiser than cholecystectomy.

Electrocardiographic studies are desirable but myocardial disease should not contraindicate gall-bladder surgery. There is increasing evidence that removal of the gall bladder may improve the cardiac condition, particularly in patients with arrhythmias. Provided these cardiac patients are compensating or can be restored to compensation by bed rest and digitalis, they present no more serious surgical risk than do those with normal hearts.

Infection of the bile by the bacilli of typhoid fever is an indication for cholecystectomy. These typhoid carriers present a public health menace through the periodic discharge of organisms into the intestinal tract. This source of infection can be eradicated only by removal of the gall bladder. Coller and Forsbeck report 88.9 per cent of cures in a series of 18 typhoid carriers operated upon and recommend that carriers who are under the age of 50 be subjected to cholecystectomy whether or not they show clinical evidence of cholecystitis. In the older patients the risk of operation is greater and discretion must be used by advising operation only when the usual indications exist.

Operative technique—Cholecystostomy. Infiltration anesthesia with procaine may be used in bad risk patients in which the simplest form of operation is to be done. Whenever circumstances permit, spinal or inhalation anesthesia is preferable since it gives more adequate exposure and enables the surgeon to do a more satisfactory operation.

The incision may be through the upper right rectus, an approach which is far from ideal anatomically but gives good exposure or it may be an oblique subcostal one in which the muscles are split in the direction of their fibers at the outer border of the rectus and sufficient of the rectus fibers divided transversely to give access to the gall bladder. The latter spares more of the nerves supplying the rectus abdominis and thereby diminishes the danger of subsequent incisional hernia. The paramedian incision is preferred by some but in males at least the gall bladder is apt to lie so far laterally as to be reached with difficulty by an approach which is so near the midline. The placing of the drain presents difficulties in this incision also although it may be brought out through a lateral stab wound.

Our preference is for the subcostal approach, the line of skin incision being one finger breadth below the costal margin and parallel with it. When the muscles are split, a finger is inserted into the peritoneal cavity and then several sutures are taken through both sheaths of the rectus down to the subperitoneal layer. These sutures prevent retraction of the muscle within the cut edges of its sheath and facilitate closure without a dead space. The incision may be extended across the midline if desired by opening the falciform ligament. Upon opening the abdomen in every case, but especially when dealing with acute inflammation, the surgeon should carefully isolate the gall bladder by gauze packs before it is opened. When the organ is tensely distended, aspiration with a syringe and hollow needle will facilitate the necessary manipulations. The gall bladder is then grasped with Allis clamps and opened at the fundus. An aspirating device with a large blunt tip should be at hand. Stones may be removed with the aid of a scoop or frequently they can be grasped with a curved hemostat. Stones impacted in the ampulla or in the cystic duct are often difficult to dislodge. However, the whole object of the operation is missed unless all stones are removed. The senior author and L. K. Ferguson have devised a cholecystoscope which is on the order of a short sigmoidoscope and carries a light at the tip. This is a great aid in visualizing the inaccessible portions of the gall bladder. When all

stones have been removed, clear bile may enter the gall bladder although often the edema about the cystic duct prevents its immediate appearance. A catgut suture should be placed through the edges of the gall-bladder wall transfixing a rubber tube. Then when a purse-string suture is placed and drawn taut, pushing of the tube downward into the gall bladder will help to invert the edges of its wall around the tube. Usually a second purse-string suture will be required to ensure a snug fit around the tube. If there is gross contamination, a soft cigarette drain should be placed alongside of the gall bladder before the wound is closed. As the skin sutures are placed and before the dressings are applied, the cholecystostomy tube should be securely anchored to the abdominal skin by two long narrow strips of adhesive tape, which in turn pass through a safety pin attached to the tube by means of a silk ligature surrounding it. We have had trouble with tubes being pulled out prematurely because they were not securely fastened in place, or because the adhesive anchorage was not renewed every 4 or 5 days. The tube should be promptly connected with a drainage bottle slung at the side of the bed and a record kept of the amount of material which drains into it. This should be included on the output side in the daily calculation of fluid balance. The usual cholecystostomy tube remains in place for from 10 to 14 days although in certain instances prolonged drainage may be desirable. Cholecystostomy, although a stop gap procedure in many instances, has resulted in cures in approximately 65 per cent of the patients upon whom we have employed it. It is our impression, although not checked, that the wounds in these cases compare favorably with the cholecystectomies as far as herniation occurrence.

Cholecystectomy. From the technical standpoint considerable muscular relaxation is essential for proper exposure. Nitrous oxide and oxygen alone will not provide this in most cases even with an expert anesthetist. Cyclopropane or ethylene may do so. Ether by open drop or in combination with other gaseous agents is the most dependable of the inhalation methods. Due to the characteristic short necked, wide chested configuration of many patients with gall-bladder disease, the endotracheal technique of administration of inhalation agents is often of great aid in insuring an unobstructed airway and controlling the depth of anesthesia. Local infiltration with novocain has been espoused by some enthusiasts but requires considerable skill and much patience. Splanchnic block has never been in great favor in this country and possesses no great advantages over spinal anesthesia. The latter is highly satisfactory for upper abdominal surgery although it must be employed with discretion due to its inherent dangers. The choice among the various suitable methods of anesthesia must be made with due regard to the particular requirements of the individual patient.

Subcostal oblique or right upper rectus incisions, as described for cholecystostomy, are used.

Operative technique. The operation should begin with an exploration which includes not only the biliary system but the stomach, duodenum, pancreas, appendix, and colon. The surgeon then knows how much must be done and is not embarrassed by the tardy discovery of unsuspected lesions at a time when the patient has had all the surgery that he can stand. The intestines are packed off and exposure obtained by the use of two or at most three retractors. One retracts the duodenum downward, the second draws the falciform ligament toward the left and the third may be required to elevate the lower surface of the liver. There is more than one way of removing a gall bladder, but we prefer first to identify the cystic duct and its relation to the hepatic and common ducts, ligate it, and the cystic artery and then proceed with the dissection of the gall bladder from its bed, beginning at the ampulla. This enables the operator to visualize clearly these structures by reason of the dry field and permits the accomplishment of the difficult and precarious portion of the operation with the best visibility. Beaver has pointed out that the textbook description of the relations of the biliary ducts obtains in only 58 per cent of the cases. In 26 per cent the hepatic and cystic duct run parallel to one another and the former may be injured if care is not exercised. Accessory ducts are present

in 8.7 per cent, the most common anomaly being an accessory right hepatic duct arising from the cystic. Ligation of this may be fatal and leaving it open will result in biliary fistula. The first step in removal is to elevate the gall bladder by placing a clamp on its ampulla, then to split the peritoneal coat over the ampulla of the gall bladder and expose the ducts. Gauze dissection will aid in exposing the cystic duct although hemorrhage may be encountered from the small veins lying anterior to it. It is helpful to remember that the veins in the plexus over the cystic duct lie parallel with it whereas over the common duct they form a network. If exposure is inadequate at this point, it is sometimes helpful to aid in the rotation of the liver by placing a gauze pack over its dome. Using a ligature carrier or a curved hemostat, two strands of No. 1 chromic catgut are passed around the duct and the latter is doubly ligated close to its juncture with the common hepatic duct. A clamp is then placed on the duct between the bladder and the ligatures to prevent spilling of bile and the duct is divided. The stump may be cauterized with phenol and the ligature nearest the common duct cut short. The other ligature should be left long as a guide until the surgeon is ready to close the wound. The cystic artery can usually be palpated even though not seen at this point and should be brought into view and ligated close to the gall bladder, since it sometimes has a branch running to the right lobe of the liver. The remainder of the operation is usually not difficult unless the gall bladder is deeply buried in the liver. As the serosal reflections are divided the gall bladder comes away from its bed. Hemorrhage is controlled by placing a few interrupted sutures of No. 0 catgut through the cut edges of the peritoneal coat. An infected gall-bladder bed should not be closely sutured. Venous ooze from the under surface of the liver can often be checked if a small bit of muscle is cut from the edge of the incision and placed against the liver surface making gentle pressure against it for several minutes. The gall bladder should not be completely severed from the liver until all bleeding is under control since as soon as this is done the liver retracts upward under the costal margin. We routinely place a soft cigarette drain in the fossa above the duodenum bringing it out on the lateral angle of the wound. We have never had cause to regret this procedure. Not infrequently bile stained drainage material for several days makes the surgeon thankful that the wound was not tightly closed. Advocates of non-drainage appear on the horizon now and then only to meet catastrophes sooner or later that make them return to the use of drainage. Moynihan once said that "as I grow older a wee bit of a drain in these cases makes me sleep better." The wound is closed in layers, a continuous row of No. 1 chromic catgut sutures being used for the peritoneum and interrupted sutures of fine alloy steel in the aponeurosis of the muscles. The skin is closed with the same steel alloy. The drain may be removed on the second or third day if the progress is entirely satisfactory. Cholecystectomy performed for gall-bladder disease uncomplicated by common duct disease, pancreatitis, etc., has given us 94 per cent cures.

COMMON DUCT OBSTRUCTION

Obstruction of the common duct whether from calculus, stricture, neoplasm of the duct itself, or the compression of an extrinsic mass will produce the characteristic manifestation of jaundice. Since the most common cause, common duct stone, is amenable to surgical relief, and the other causes may be relieved, if not cured, most patients with common duct obstruction should be given the benefit of operative exploration. Hemolytic icterus and intrahepatic biliary obstruction should be excluded by laboratory tests of which the Van den Bergh bromsulphthalein and blood fragility tests are the most significant. Estimation of the degree of jaundice is of importance and, whereas the hue of the skin and the color of the stools serve as a rough guide, a determination of the icteric index is more accurate. When the obstruction is due to a progressive lesion such as stricture or neoplasm, the jaundice also is progressive and relentless. With common duct stone there are usually periods during which some bile flows into the duodenum and the jaundice accordingly lessens intermittently. Patients with common duct

obstruction present serious risks for surgery because there is coincident liver damage and also because of the hemorrhagic tendencies inherent to jaundice. The time for operation must be chosen with discretion. As a general rule it is inadvisable to operate while the jaundice is increasing unless it is obvious that a desperate chance must be taken. On the other hand, when the jaundice is clearing, it is well to wait for the maximum improvement. If the level of jaundice reaches a peak and levels off, nothing is gained by further delay.

Prior to operation the ordinary fluid and nutritional requirements must be met and special measures must be instituted. We know that the livers of jaundiced patients are deficient in glycogen and infiltrated with fat. The administration of glucose is imperative because it serves as a source of energy which can be easily metabolized and this obviates further depletion of liver glycogen. In addition to its value from the metabolic standpoint, glucose exerts a favorable effect upon blood coagulation reducing the tendency to hemorrhage. Many patients are able to take sufficient quantities by mouth in the form of sweet fruit juices or hard candy. The oral route should always be used when available; otherwise glucose may be given intravenously. The other important anticoagulant measure is the transfusion of blood. Small amounts (100 c.cm.) given repeatedly are of great value. In the presence of anemia larger transfusions should be employed since reduction in red corpuscles greatly increases the operative risk. Calcium has had a vogue as an anticoagulant although there never has been adduced definite evidence that reduction in serum calcium is associated with delayed blood coagulation or that clotting is favorably influenced by the administration of the calcium salts. We place no reliance upon it.

The anesthetic agent and the method used must avoid damage to liver cells or disturbance in the blood sugar level. At the same time it must provide sufficient muscular relaxation for adequate deep exposure. Aside from the necrotizing effect on liver cells of such an agent as chloroform, the damage to the liver from an anesthetic is that of the associated anoxemia. Nitrous oxide, avertin, or the barbiturates are poorly suited since to maintain surgical anesthesia the concentration of oxygen in the respiratory exchange is reduced to a dangerously low level. More potent anesthetic gases, such as ethylene or cyclopropane, permit the addition of larger proportions of oxygen and are more desirable from this standpoint at least. Ether is accompanied by some reduction in oxygen capacity and content and has a disturbing effect upon blood sugar. Nevertheless its obvious advantages are recognized and it may be used with impunity in cases of early or mild disease of the liver. Local infiltration with novocain usually fails to provide the exposure required by the surgeon. Spinal anesthesia obviates this defect and also the undesirable toxic effects. There may be contraindications to the use of spinal anesthesia from the standpoint of the cardiovascular mechanism and in such cases resort may well be to ethylene or cyclopropane provided the skilled anesthetist required for their use is available.

Operations. The problems of preparation for operation, choice of anesthesia and postoperative care, are common to all cases of surgical jaundice regardless of its cause. The operative procedure will vary, depending upon the cause of the obstruction of the duct. At this point certain general principles concerned with obstruction of the common duct by stone will be dealt with. In the presence of strictures of the ducts or of malignancy the procedure is covered in the discussion of these subjects.

It frequently happens that the diagnosis of an obstruction of the common duct is not obvious before operation and at the moment jaundice is absent. In such cases, the surgeon must have certain criteria for opening and exploring the duct. The favorable statistics from large clinics to the contrary, there is no doubt that in average hands the morbidity and mortality will be increased by this procedure over that which will follow surgery confined to the gall bladder. Exploration of the duct should not be done as a routine but it ought not to be omitted (1) when there is a history of jaundice, hepatic fever, acholic stools, etc.; (2) when a stone can be palpated in the duct even though there has been no jaundice;

(3) when the common duct is dilated, thickened, or has lost its normal bluish color and appears white or grayish. Unless these rules are followed, stones will be overlooked, and secondary operation may be required.

Eliason and Erb recently reported that they had explored the common duct in 18 per cent of a large series of biliary operations with the discovery of stones in the duct in 10 per cent of the total number of cases. When the duct is opened a drainage tube should always be introduced as suture of the duct can not be relied upon.

As a general rule the gall bladder should be removed at the same time that the duct is explored, since it represents a focus of infection even though the disease has extended beyond it. In certain instances, however, it is the part of wisdom to do a cholecystostomy and leave the gall bladder in place. Such occasions arise when the nature of the obstructing lesion is such that it may progress after operation or when the surgeon is uncertain whether he has completely and effectively removed the cause of the obstruction.

In the event of a secondary operation, the preservation of the gall bladder serves as a useful anatomic landmark in what is apt to be a tedious dissection and also makes it feasible to perform a subsequent short circuiting procedure should it be required. We have made it a rule to save the gall bladder in this way whenever the common duct is large and contains many small stones. The following case illustrates the value of this:

A man, 48 years of age, was first operated upon in 1931, for recurrent attacks of epigastric pain and jaundice. Stones were found in the gall bladder, the common and hepatic ducts, and cholecystostomy and choledochostomy were done. During the ensuing 6 years five additional operations have been performed on this patient usually because of recurrences of pain and jaundice. No further stones have been encountered in the gall bladder but in each instance except the last a large number of soft stones have been found in both the hepatic ducts and in the common duct. The last operation was done for persistent biliary fistula. The gall bladder has not been removed in this patient because it has not contained stones since the first operation. The evidence indicates that this patient's calculi have originated in the liver or hepatic ducts. At each operation the author has been thankful for the presence of the gall bladder as a guide leading to the common duct.

Choledochostomy. Anesthesia requirements in the jaundiced patient are important and are covered in the discussion of common duct obstruction. The incision may be the subcostal oblique or the right upper rectus which have been described in connection with cholecystostomy. The common duct is exposed in a manner outlined for cholecystectomy. With the oblique incision, improved exposure of the duct is obtained by extending the incision across the midline. If adhesions are present they must be carefully separated employing the gall bladder and the cystic duct as a guide leading toward the common duct. The latter appears as a faintly bluish structure beneath the peritoneum in the right free margin of the gastrohepatic omentum. It is overlaid by a plexus of small veins which, if dilated, may give troublesome hemorrhage. When doubt arises concerning which of the structures in the gastrohepatic omentum is the common duct, the aspiration of bile with a fine hypodermic needle attached to a syringe will settle the matter. Two sutures of fine (No. 00) catgut are placed in the wall of the duct by means of a small curved intestinal (Ferguson No. 12) needle, the ends of the suture are left long and clamped to serve as tractors. The duct is then incised in the direction of its long axis between the traction sutures. As the bile pours out it is sucked up by an aspirating apparatus with a fine tip or absorbed by a gauze sponge. The opening is enlarged to admit a duct probe or even the finger. The duct is explored toward the duodenum and then upward in an attempt to locate the obstruction. The thumb and forefinger of the surgeon placed behind and in front of the duct will aid in this exploration and may assist in displacing a stone upward. In conducting this exploration the surgeon can sometimes benefit by taking his position on the left side of the patient and inserting his left hand into the wound. Stones may be exceedingly difficult to dislodge but sometimes may be grasped by a curved hemostat or stone forceps. When numerous small stones or gravel are encountered, they may be washed out. A woven silk catheter (No. 10–12 F.) is passed down the duct to irrigate it with warm normal saline solution. An ordinary soft rubber catheter is apt to kink upon itself and

woven silk ones are much better. During the irrigation care must be taken not to wash material upward into the hepatic ducts. This may be prevented by plugging the latter with a small piece of narrow gauze packing. After the lower portion of the duct has been washed clean and the catheter passes freely past the sphincter of Oddi into the duodenum as evidenced by the fact that none of the irrigating fluid returns, the procedure should be reversed and the hepatic ducts irrigated in turn.

Before removal of the catheter passing into the duodenum, the operator standing on the patient's left should palpate with his left thumb and forefinger along the duct as outlined by the catheter. This palpable guide will facilitate the disclosure of a stone ofttimes that has up to this stage been overlooked.

Frequently after one is sure that all stones are removed the catheter cannot be passed into the duodenum. This obstruction may be due to the fact that the catheter tip is unable to find the sphincter opening because of its eccentric position with relation to the dilated portion of the duct above it. When this is the case, if the woven catheter is bent about ¾ of an inch from its tip so as to form an angle of 15 to 20 degrees to the rest of the catheter, and then inserted and rotated on the long axis while gently pushing upon it, the sweeping tip will often find the eccentric sphincter.

The author routinely drains the common duct with a rubber T-tube. Some surgeons use plain or mushroom catheters. The former slip out too easily and the latter may be difficult to remove. If certain precautions are observed with the T-tube, it will prove very satisfactory. It must not be of soft collapsible material nor on the other hand should it be so stiff as to traumatize the duct. The side arms should be about ¾ inch in length and the ends bevelled on their anterior aspects. A notch cut in the cross arm opposite the upright portion allows the side arms to fold and slip out readily when the time comes to remove the T-tube. Interrupted sutures of fine catgut are placed in the wall of the duct above and below the emerging tube to give a snug watertight joint but care must be taken not to narrow the duct in approximating the cut edges. In most cases a cigarette drain should be placed in the fossa above the duodenum as a precaution before closure of the wound.

Stones impacted in the duodenal portion of the common duct are particularly difficult to dislodge. In some cases it may be necessary to mobilize the duodenum by freeing its superior and lateral attachments and then rotating it forward to expose the posterior wall through which the lowermost portion of the common duct passes. Occasionally a stone in this position can only be removed by a transduodenal approach to the sphincter of Oddi.

Postoperative care. After operation these patients have the same need of glucose and blood as before. In addition there are certain problems introduced by the diversion of bile through a choledochostomy tube. The flow must be unimpeded and the tube may have to be gently irrigated with warm saline solution. Too rapid decompression of the biliary system may have untoward effects. The same care must be exercised in this respect as is needed following thoracotomy for empyema or the evacuation of a long standing distention of the urinary bladder. The bile should flow out of the drainage tube intermittently or the tube connected with a decompression apparatus so that the drainage occurs slowly against the pressure of a column of water or gravity. Moreover, the complete diversion of the patient's bile may result in profound biochemical disturbances through the loss of bile salts and other electrolytes. Patients whose bile and pancreatic ferments are being lost in this way sometimes develop marked listlessness, low blood pressure, nausea and debility, sometimes termed "pancreatic asthenia." The deficit can be corrected either by clamping the choledochostomy tube for a long time if this be feasible or perhaps better by returning the bile to the gastro-intestinal tract by pouring it down a duodenal tube which has been introduced into the stomach. As an alternative the bile may be collected, lyophilized (concentrated) and given to the patient in convenient capsules (Mudd). The patient's own bile or that of another patient serves far better as a corrective under these circumstances than does any synthetic chemical substance or ox bile. The length of time a tube is left in the common duct depends upon the circumstances

of the case, e.g., the amount of bile passing through the sphincter of Oddi by the normal route and the degree of hepatitis present. Ordinarily 2 weeks is a sufficient period for drainage but occasionally prolonged drainage of several months is desirable. It is of the greatest importance in these patients to observe both clinically and by laboratory tests the progress of the jaundice. The color of every stool passed or the return from each enema should be carefully noted on the patient's record for this gives a reliable index of the flow of bile through the normal channel into the intestinal tract.

STRICTURES OF THE BILIARY DUCT

Although other etiological factors are possible, the majority of strictures are the result of operative trauma. Their correction presents one of the most difficult problems in abdominal surgery and the operative mortality rate is high; therefore, the utmost caution should be exercised to avoid damage to the ducts in doing biliary surgery. Two or three dangerous practices in the performance of cholecystectomy deserve particular attention. When troublesome hemorrhage occurs from the cystic artery a clamp or a ligature carelessly placed may include the right hepatic duct together with the cystic artery. The same error may be made by placing a clamp blindly on the neck of the gall bladder preparatory to dividing the cystic duct. To insure against this the cystic artery should always be distinctly visualized or palpated and ligated close to the gall bladder either before or immediately after ligation of the cystic duct. If the cystic artery be accidentally torn, a clamp should never be placed blindly in a field obscured by blood. A second common error arises in making strong traction upward on the gall bladder so that the junction of the cystic with the common hepatic and common ducts is peaked. Under these circumstances the ligature intended for the cystic duct may encircle the common hepatic or the common ducts either in entirety or in part. The result will be a biliary fistula if the misplaced ligature blows off or, depending upon how much has been included in the ligature, a partial or complete stricture of the common duct. The possibility of these calamitous sequellæ is ample justification for the absolute dictum that cholecystectomy should never be attempted in cases in which the relations of the three ducts can not be visualized.

The surgeon who opens an abdominal cavity for the repair of damage to the biliary ducts invariably faces a trying and tedious session. The omentum and duodenum will usually be found adherent to the under surface of the liver at the former site of the gall bladder. The identification of the common duct itself may be an exasperating and time consuming problem. Having identified the ducts and demonstrated the level and nature of the stricture, several possibilities present themselves for overcoming the obstruction.

An adequate length of duct proximal to the stricture is a prerequisite to any form of anastomosis. The latter must be accomplished without tension on the suture line and to ensure this it is easier to mobilize the duodenum and draw it upward than to make any downward traction upon the duct itself. An ideal procedure would be a resection of the narrowed portion of the duct and an end-to-end anastomosis. This is feasible only with very short strictures as otherwise tension will ensue. The sutures must be meticulously placed and should be of the finest material and the needle should be small. Care must be taken to avoid inversion of the edges of the duct wall, thus giving rise to a new stenosis. A rubber tube should be used to maintain patency of the duct during the stage of edema following operation. If anastomosis can not be done, the proximal portion may sometimes be implanted into the mobilized duodenum—hepaticoduodenostomy or choledochoduodenostomy. Plastic procedures to overcome narrowing are rarely applicable. One of the Heineke-Mikulicz type which is satisfactory in correcting pyloric stenosis will produce kinking if attempted on a bile duct. Occasionally a stricture may be split in the axis of the duct and sutured around a tube. The senior author has successfully followed the suggestion of Dr. Julian Johnson that parallel relaxation incisions be made in the duct and a tube be placed in the lumen. Lahey has suggested that as a last resort if insufficient proximal duct tissue is

present, a biliary fistula be allowed to form and the tract of the latter then be dissected out of the abdominal wall and implanted into the stomach or duodenum. Every one of these procedures will tax the skill of the ablest surgeon. A leak in the suture line may jeopardize the entire result. Furthermore the dangers of cholemic hemorrhage common to all jaundiced patients exact a large toll and the mortality rate is high even with the best of technical performances.

BILIARY FISTULA

The continued discharge of bile through an opening in the abdominal wall after operative tube and drains have been removed, should occasion some perturbation on the part of the surgeon in attendance. It is to be expected that some leakage will occur for a few days following the removal of a cholecystostomy or choledochostomy tube but within a short time all of the bile should be passing through the normal channel into the duodenum. Continued drainage should arouse the suspicion of an obstruction of the duct. This may be due to a stone or to a misplaced ligature. Other and more favorable possibilities are that an accessory cystic duct was not observed during cholecystectomy and is discharging bile through the wound or that the ligature has slipped off the stump of the cystic duct. In both these latter cases the normal bile passageway into the intestinal tract is patent and under such circumstances the biliary fistula may in most cases be expected to close spontaneously. The importance of the factor of obstruction in the persistence of fistula is well illustrated in the case of drainage of the gall bladder without the extraction of an impacted stone in the cystic duct. Here a more or less continuous communication will persist between the gall bladder and the opening in the skin. It will in this instance discharge mucus rather than bile because the latter is prevented by the impacted stone from reaching the gall bladder, but its behavior is quite different from that following cholecystostomy with a patent duct. The decision to operate or to wait for spontaneous closure in a biliary fistula depends therefore upon the demonstration of the presence or absence of obstruction. Jaundice or clay colored stools give a clue but much more exact information concerning the level and nature of an obstruction is obtained by fluoroscopic observation during and immediately after the injection of a radio-opaque substance, such as iodized oil, into the fistula. This gives a clear delineation of the ductal system and should reveal the true situation. If the injected oil passes readily into the duodenum, operative intervention should be deferred for at least a year. The demonstration of a stone in the common duct calls for choledochostomy. Strictures of the duct require appropriate measures. The final recourse is a dissection of the fistulous tract with implantation of it into the stomach or duodenum. This operation is neither as easy nor as successful in practice as it sounds in theory.

CANCER OF THE GALL BLADDER AND EXTRAHEPATIC BILIARY DUCTS

Carcinoma has been estimated to be found in between 1 per cent and 2 per cent of all cases of disease of the gall bladder and its ducts. This incidence, therefore, is less than the mortality of the best elective cholecystectomy and the removal of silent gall stones can not therefore be urged on the ground of their threat of the development of cancer. The diagnosis of cancer confined to the gall bladder is rarely made before operation and later frequently only by histopathological examination. The obvious surgical procedure is a cholecystectomy unless the growth has extended beyond the confines of the gall bladder.

Cancer of the ducts manifests itself by relentless and painless jaundice. Potter has called attention to the fact that it occurs about as frequently as cancer of the head of the pancreas and about 3 of 5 cases are erroneously so diagnosed.

It is well known that surgical attack on carcinoma of the ducts presents much the same problem as stricture with the additional urgency to perform radical extirpation when feasible. A few cases of successful resection of the common duct with implantation of the stump into the duodenum are on record. More often the only possible course open to the surgeon will be a palliative cholecystogastrostomy or cholecystoduodenostomy.

CONCLUSIONS

Early surgery in the acute attack as well as in the course of the disease will reduce mortality and morbidity. Judicious choice of the procedure to be employed is necessary. The surgeon should recognize his own as well as his patient's limitations. It might be better to leave a difficult case of impacted stone behind the duodenum until drainage through a cholecystostomy relieves the dangerous jaundice.

Postoperative care is extremely important. It should be directed toward the prevention of hypoventilation and pulmonary complications by posture, deep breathing exercises, change of position, suction drainage of the stomach as a defense against abdominal distention, the prevention of concealed hemorrhage and biliary peritonitis by the use of a drain, the maintenance of liver function by the use of decompression drainage and the administration of blood or glucose and salt intravenously to sustain metabolic and fluid balance. Only by strict attention to these principles can we hope to reduce the mortality and morbidity of biliary disease.

REFERENCES

1. Beaver, M. G. Arch. Surg., 1929, 19: 321.
2. Coller, Frederick, and Forsbeck, F. C. Ann. Surg., 1937, 105: 791.
3. Eliason, E. L., and Erb. Ann. Surg., 1935, 101: 460.
4. Eliason, E. L., and Ferguson, L. K. Surg. Clin. N. America, 1928, 8: 840.
5. Flint, E. R. Lancet, 1933, 224: 187.
6. Graham, H. T. Am. J. Surg., 1936, Nov.
7. Heuer, George J. Ann. Surg., 1937, 105: 758.
8. Judd, E. S., and Phillips, J. R. Ann. Surg., 1933, 98: 771.
9. Lahey, Frank. Ann. Surg., 1937, 105: 765.
10. Mason, J. T. J. Am. M. Ass., 1932, 99: 891.
11. Miller, Richard H. Ann. Surg., 1930, 92: 644.
12. Mudd, Stuart, and Flosdorf, E. W. J. Immunol., 1935, 29: 389.
13. Potter, E. B. Ann. Surg., 1933, 98: 369.
14. Smith, Morris K. Ann. Surg., 1933, 98: 766.
15. Stone, Harvey, and Owings, J. C. Ann. Surg., 1933, 98: 760.
16. Taylor, Frederick. Surg., Gynec. & Obst., 1936, 63: 296.
17. Zinninger, M. M. Ann. Surg., 1932, 96: 406.

OBSTETRICAL INFLUENCES ON THE WEIGHT CURVE OF THE NEWBORN

W. C. C. COLE, M.D., Detroit, Michigan

THE conception that the "normal" newborn infant may be in a state of mild shock is relatively new. If such a conception proves to be correct, it should greatly modify not only our routine care of newborn babies but many obstetrical procedures.

Practically all laymen and most physicians think of labor from the mother's point of view. The baby usually receives scant attention until the process is over. Many procedures have been advanced in recent years to make labor easier for the mother but very few have been suggested to make delivery safer for the child. After all, the function of labor is to produce healthy children. True progress in obstetrics should certainly be as much concerned with insuring the baby's safe passage through the birth canal, as with making labor more endurable for the mother.

A most casual inspection of newborn statistics should be sufficient to convince anyone that this is not an insignificant problem. In hospital practice, about 4 per cent of the newborn babies are either stillborn or die in the first week of life. More than half of these are due to accidents of labor, especially cerebral injury and asphyxia. It is estimated that about seventy thousand recognized cases of cerebral hemorrhage in the newborn occur in the United States each year. A very large proportion of the inmates of public institutions for the mentally or physically handicapped are cases resulting from birth injury. Therefore it seems appropriate that we gather data which may throw additional light upon the factors responsible for these injuries.

Labor in the human is quite a different problem from that in even the largest of the mammals because of the large size of the infant's head and the disproportion between it and the mother's pelvis. It has been suggested that the amount of trauma to the head, which is necessary under even the most ideal conditions, is sufficient to produce a considerable degree of shock in the infant. Changes in blood pressure, blood volume, and blood flow in newborn babies, similar to those found in patients with surgical shock have been reported. Clinical evidence of this shock is the apathy, refusal of food, and marked loss of body weight almost invariably observed during the first days of life.

The loss of weight has always been called "the physiological weight loss of the newborn." It has been explained by the loss of meconium and urine from the body, by the vomiting of mucus, and by the fact that the baby usually receives little or no food or fluid during the first days of life.

If we examine the growth curve of the ovum from the time of fertilization until birth, we will observe that it is rapid and continuous. Also, if we examine the growth curve of the infant after it has recovered from the effect of birth, it is again rapid and continuous. It does not seem reasonable that such a marked interruption of development, sometimes involving a loss of 10 per cent of the body weight can be a "physiologic" phenomenon. Furthermore, if the various factors usually listed as accounting for this loss of weight are all added together, they are sufficient to explain only a part of the weight lost by most babies. Apparently some changes must occur which have not previously been considered.

One of the outstanding features of "shock" is a disturbance in the water metabolism involving the loss of large amounts of water from the body, chiefly through the skin and lungs. The work of Coller[1] on the water metabolism of patients after operation has demonstrated this thoroughly. While similar studies have not been made on newborn infants, the analogy between them and adults after operation seems sufficiently close to

[1] COLLER, F. A., and MADDOCK, W. G. J. Am. M. Ass., 1932, 99: 875–880.

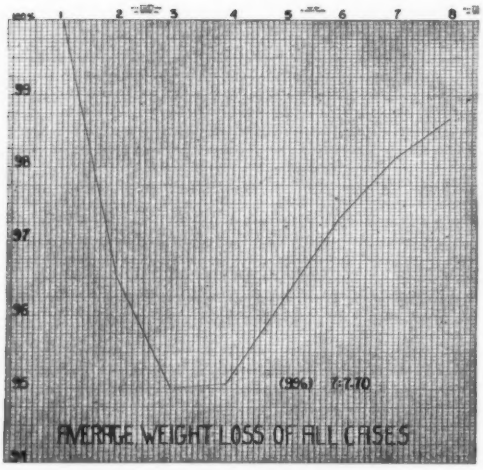


Chart 1. Average weight loss of all cases.

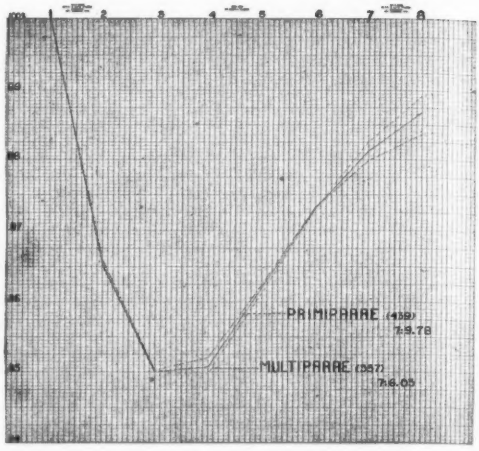


Chart 2.

assume that similar processes are taking place. If this be true, the weight lost by the newborn is largely due to water lost from the body and should be more or less an index to the degree of shock.

In the observation of a large number of newborns, we have been impressed by the fact that babies of similar size, apparently born under similar conditions, and fed and cared for in like manner, vary widely in the amounts of weight which they lose. Some factors obviously must be operative in one case which are not present in the other. If birth shock is a factor in some of these cases, conditions during and after labor which might tend to increase the birth trauma should be possible of detection by an inspection of the delivery record.

With this in mind, we have collected a considerable series of cases on which accurate observations of many of the possible factors which might involve the baby, including the food and fluid intake, were carefully recorded and tabulated in such a manner as to make comparison of their various weight curves possible.

In this paper we wish to present an analysis of the influence of various obstetrical and neonatal procedures on the weight curves of different groups of infants. The consideration of the food and fluid intake and a correlation of the two series will be the subject of a later report.

Between November, 1935, and June, 1936, records were made of all the babies born in the Woman's Hospital at Detroit. These included all social groups and were delivered by physicians with a considerable variation of obstetrical training. Accordingly, a very good general cross section was obtained. During this period, about 1,250 babies were born. Only normal children were included in this study. Any baby who was ill or had a recognized abnormality or whose record was not complete was excluded from the series. The babies in this series left the hospital at the usual time in apparently good condition. This left a group of 996 babies which form the basis of this analysis.

The data were tabulated according to the punch card method. All data concerning each child were punched into an individual card according to a previously established code. This included data about the pregnancy, delivery, neonatal period, the weight for each of the first 8 days, and a complete record of the food and fluid intake for each day. After the cards were complete, it was a simple matter to sort them into any desired group or subgroup by means of a mechanical sorting machine, and to obtain the cumulative weight

curve of any given group by means of a tabulating machine. This permitted analysis of data which would be impossible by means of ordinary hand methods and in addition assured absolute accuracy.

The weight curve for the whole group is shown in Chart 1. This and all subsequent curves are expressed in percentage of the birth weight, rather than in ounces, so as to make comparison of groups of different weights on a common basis. The birth weight is taken as 100 per cent. Figures in parenthesis indicate the number of babies. The other figure is the average initial weight. The loss in weight the second day was 3.47 per cent. The maximum loss occurred on the third day and was exactly 5 per cent of the original weight. This represents a loss of almost exactly 6 ounces for the average baby. Only a very slight increase occurred on the fourth day but from then on the gain in weight was rapid and continuous. On the eighth day, the average baby was 1.33 per cent below birth weight. The maximum loss of 5 per cent of the birth weight is considerably less than the figure usually given for similar groups. VonReuss gives from 6 to 10 per cent as the usual loss. This is probably due to the fact that practically all of the babies in the nurseries at the Woman's Hospital are offered fluids of one sort or another during the first days of life. This, however, is a question which we will discuss at another time.

Chart 2 shows the comparative weight curves of the babies of primiparæ and multiparæ. VonReuss states that the children of primiparæ lose more weight and recover more slowly than those of multiparæ due to the later appearance of the mother's milk. In our series, the curves are practically identical except that at the eighth day, the babies of the primiparæ have not regained as much of their weight. If the trauma of labor is a factor in increasing the weight loss of the newborn, it might be expected that it would be greater in the case of primiparæ, but this is obviously not the case. However, as will be subsequently shown, the duration of labor which is usually much longer in the primiparæ, may tend to offset such an effect.

Chart 3 shows the effect of the various types

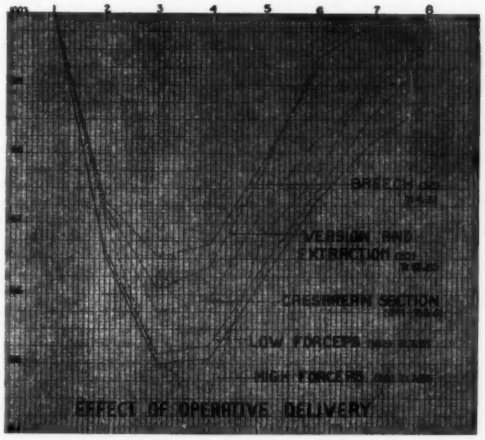


Chart 3. Effect of operative delivery.

of operative delivery on the weight curves of the newborn. It will be noted that all but one group (high forceps) lost less than the average. While the curve is not shown on this chart, obviously babies born by normal delivery lost correspondingly more than the average. There were 32 babies born by breech delivery in which the maximum loss in weight was but 3.47 per cent. This group was over birth weight on the seventh day. There were 20 babies delivered by version and extraction in which the maximum weight loss was 3.92 per cent. They were practically at birth weight on the eighth day. There were 34 babies born by cesarean section in whom the maximum loss was 4.25 per cent. They were 0.50 per cent below weight on the eighth day.

It should be noted that in all three of these groups, trauma to the head is either absent or greatly reduced because it is not the presenting part and does not receive direct pressure as in the case of cephalic presentation. There were 182 cases in which low forceps were applied The loss in this group is only slightly less than the average but very definitely so when the size of the group is taken into account. Their better recovery by the end of the period is also significant.

There were 28 cases in which high forceps were applied. The weight curve of this group closely corresponds to the average except for

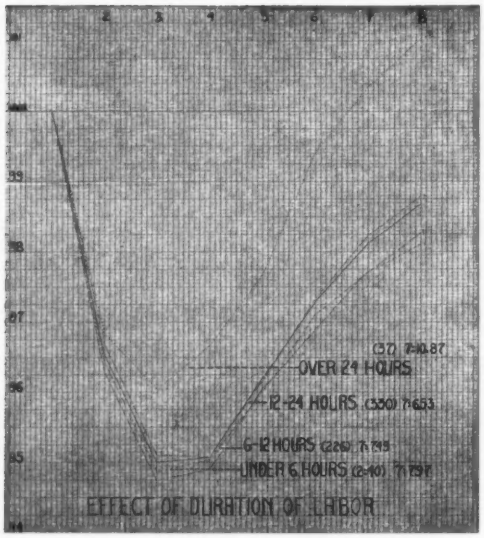


Chart 4. Effect of duration of labor.

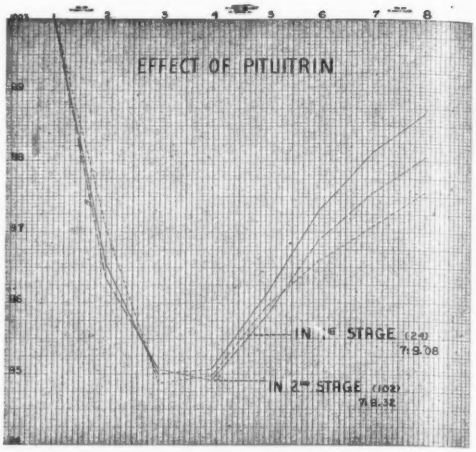


Chart 5. Effect of pituitrin.

the continued loss of weight into the fourth day. This could perhaps be interpreted as the result of increased trauma but is more probably due to special feeding problems. Mothers in whom high forceps application is necessary would probably be in poor condition longer than the average mother with a consequent reduction in milk production.

It has been suggested that in the case of breech and version deliveries, meconium is often expelled during labor so as to make the original weight less and the percentage loss correspondingly less. However, it appears that meconium is only occasionally expelled and then rarely as much as an ounce. If we should recalculate these cases on the basis of one ounce more on their original weight (which does not seem likely) their weight curve then would be very close to the cases delivered by caesarean section.

In any event, it seems very striking that in the groups in which trauma to the head is minimized, the weight loss of the babies was markedly reduced. There is also room for argument that the use of low forceps, toward the second stage of labor, somewhat reduces the trauma to the baby's head.

Fully as significant as the original loss in evaluating the amount of injury to the baby is the very considerably faster recovery made by all of these groups. These results should not be interpreted as favoring breech and version delivery. These records are only on normal babies. It is well known that the incidence of tentorial tears is much higher in this type of delivery.

Chart 4 shows the effect of the duration of labor upon the weight curve of the baby. The cases were divided into four groups. Those in which the labor was less than 6 hours, in which it was from 6 to 12 hours, from 12 to 24 hours, and over 24 hours. There seems to be little if any difference in the curves of the babies in the first two groups. Both of them lost slightly more than the average and are significantly slower in their recovery by the eighth day. The 12 to 24 hour group conforms almost exactly with the average but the loss is slightly less throughout. However, in the group in which labor lasted over 24 hours, the difference is extremely striking. The maximum loss was but 3.96 per cent, and they were 1.07 per cent above birth weight on the eighth day. Long slow labors are often the result of weak pains. This marked reduction in the weight loss of this group, coupled with their very good recovery, strongly suggests that slow gradual progress of the child through the birth

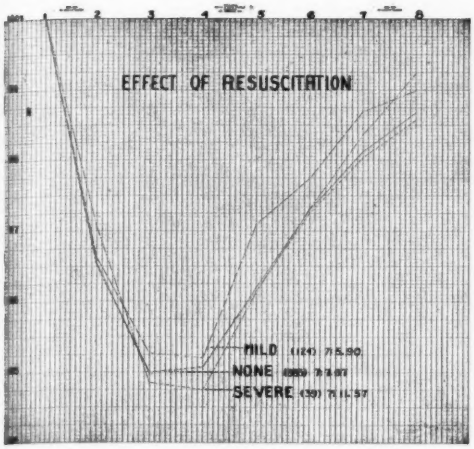


Chart 6. Effect of resuscitation.

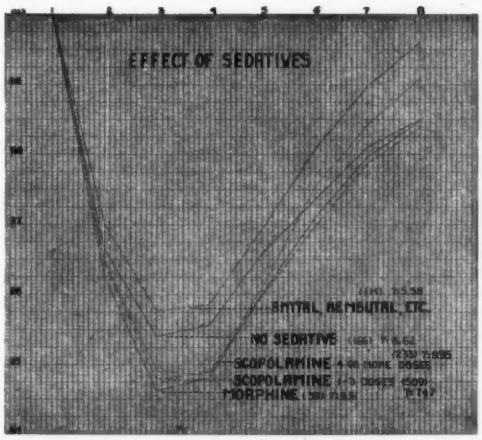


Chart 7. Effect of sedatives.

canal tends to minimize the trauma to the head.

Chart 5 shows the effect of pituitrin on the weight curve of the infant. There were 24 cases in which pituitrin was used in the first stage of labor and 102 in which it was used during the second stage. The initial weight loss of both groups does not seem to show any significant deviation from the average curve although both groups lost slightly more. In both cases, however, the recovery is slower than average and when pituitrin was used in the first stage, the babies were 2.44 per cent below weight on the eighth day. This is nearly twice as much below weight as the average baby. Whether this bears any relation to the use of pituitrin or is merely an accidental finding is open to question. It would naturally be expected that the pituitrin would increase the trauma to the baby's head, but if so it is not indicated in the amount of the initial loss.

Chart 6 shows the effect of resuscitation in the newborn on the subsequent weight curve. The cases were divided into two groups, those in which the asphyxia was mild, and those in which it was severe. Severe cases were those with prolonged cyanosis, in which the tracheal catheter was used or in which artificial respiration was needed.

The curve of those babies in whom resuscitation was not used, corresponds almost exactly to the average. When mild measures were necessary the loss was slightly less; when severe measures were used it was slightly more. If there is any significance to these findings, it is not clear to the writer.

Chart 7 shows the effect of sedatives given to the mother on the infant's weight curve. These are divided on the following basis, no sedative, scopolamine 1 to 3 doses, scopolamine 4 or more doses, morphine (usually in combination with scopolamine), and amytal, nembutal, etc.

In cases in which patients received no sedative the babies lost considerably less than average (4.59 per cent). Those receiving amytal, etc. lost a maximum of 4.23 per cent, which is strikingly less than average. Recovery in this group was also better than in any other. The amount of scopolamine given did not seem to alter the curves of those two groups nor did the addition of morphine cause any appreciable change. All of these latter groups lost slightly more than average and were somewhat slower in recovery. There are two possible explanations for these findings. Amytal, etc., act quite definitely to slow labor, whereas scopolamine does not. Babies whose mothers receive amytal are usually very listless and apathetic for the first 24 hours. Scopolamine seems to render the baby hypertonic and irritable. The energy conserved in

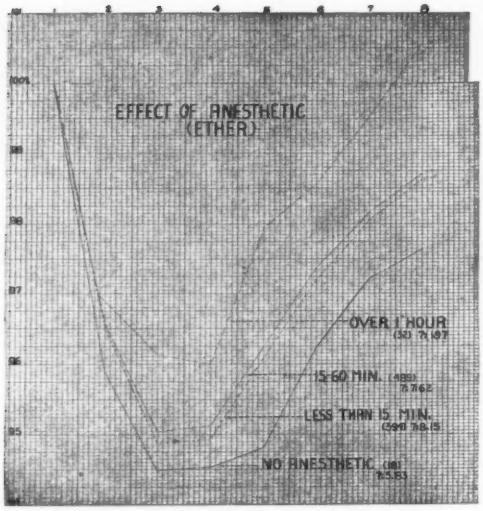


Chart 8. Effect of anesthetic, ether.

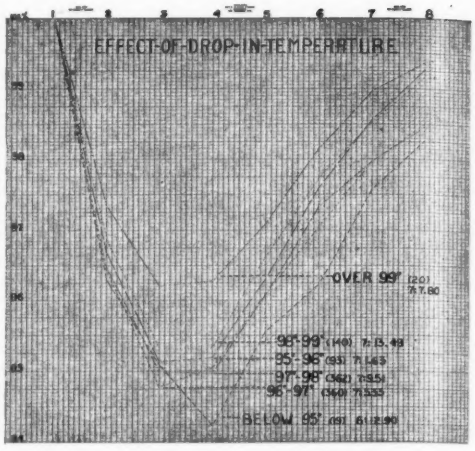


Chart 9. Effect of drop in temperature.

the first group might possibly reduce the weight loss, or the depression of respiration might cause less water to be lost through the lungs. The effect, however, seems very definite. The interpretation will bear further study.

Chart 8 shows the effect of ether administered to the mother on the weight curve of the baby. The cases were divided into those receiving no anesthesia, those receiving ether for less than 15 minutes, those receiving ether from 15 to 60 minutes, and those receiving ether for over 1 hour. It is very evident that the amount of ether administered to the mother bears a direct relationship to the initial weight loss of the infant and to the rate of recovery of the weight. The more ether the mother received, the less the baby lost and the more rapid the recovery. When no anesthetic was given, the maximum loss was 5.53 per cent and the babies were still 2.37 per cent below weight on the eighth day. When ether was given for over 1 hour, the maximum loss was 4 per cent and weight at the eighth day was +.58 per cent. There are several possible interpretations of this very interesting observation. It might be that the administration of ether slows down the progress of labor, it may have a direct effect on the child's nervous system, or as seems quite likely, it might modify the baby's respiration with consequently reduced water loss from the lungs.

Whatever the explanation, the effect seems so definite as to leave little doubt that ether given to the mother tends to reduce birth shock in the baby.

Chart 9 shows the effect of the drop in the baby's temperature during the first hours after birth. The cases are divided into groups according to the lowest point the temperature reached in the first 24 hours after birth, one group for each degree. It will be observed that with a single exception (those between 95 and 96 degrees) the drop in weight is directly proportional to the drop in temperature. It is possible that in the exceptional group special administration of parenteral fluid may have been used in certain cases which modified the curve of this group. The maximum loss in those in which the temperature fell below 95 degrees was 5.77 per cent while in those where it did not fall below 99 degrees, it was but 3.80 per cent. The regular progression upward of the weight curve with each degree of rise in temperature is very striking and must be significant. The rate of recovery is also proportional to the original loss. The temperature of the delivery room was never below 85 degrees and usually near 90 degrees. Heated cribs are provided for the reception of

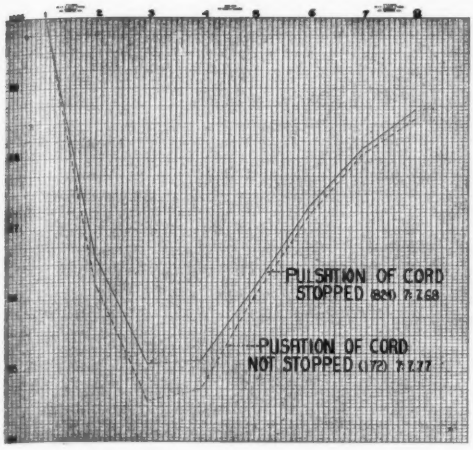


Chart 10.

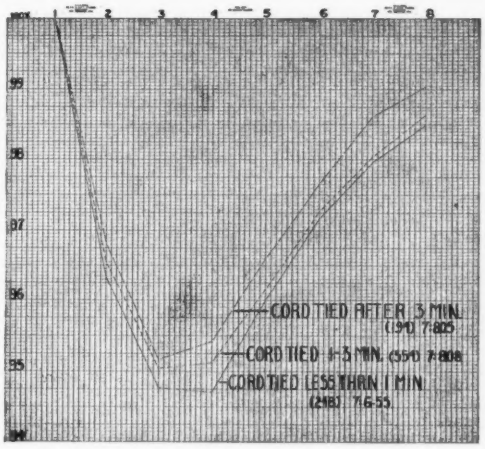


Chart 11.

each infant. It would seem that the reason for the variation in the drop in temperature lays not in external influences but to conditions within the babies themselves. It may be that the drop in temperature is in itself responsible for the increased loss in weight but it seems much more likely that the drop in temperature is merely another method of measuring the degree of birth shock. Lowered body temperature is one of the characteristics of shock and it would be natural to find the loss of weight corresponding to the drop in temperature if we assume that both of these factors are indices of shock.

Charts 10 and 11 show the effect of the time of tying the umbilical cord on the babies weight curve. In Chart 10, the cases are divided into two groups according to whether the cord was tied before or after pulsation had stopped. It will be seen that when the cord was tied before pulsation stopped the loss in weight was distinctly greater and that the curve remained below the other group throughout. In Chart 11, the cases were divided into three groups: (1) the cord was tied in less than 1 minute after birth; (2) it was tied between 1 and 3 minutes after birth; and (3) it was not tied until more than 3 minutes after birth. It will be readily seen that the longer the time that elapsed, the less the weight the babies lost. It has been estimated that the baby receives from 1 to 2 ounces more blood (a very considerable amount to a newborn) when the cord is not tied until after pulsation stops than when it is tied at once. Inasmuch as blood volume is one of the important factors in the

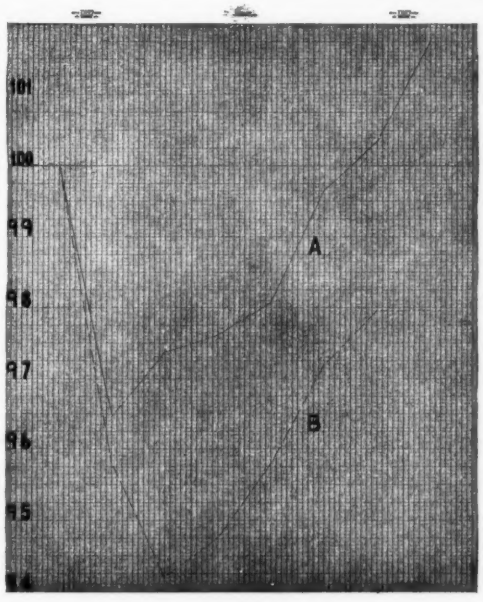


Chart 12.

determination of shock, it is easily conceivable that the loss of blood by the early tying of the cord might tend to increase an existing tendency to shock.

Chart 12 shows the result of selecting cases in which several of the favorable factors are present and another group in which the corresponding unfavorable factors are present. Group A represents a group of 32 cases born by non-cephalic presentation, in which the duration of labor was over 12 hours, in which the temperature never fell below 98 degrees, in which ether was administered for 15 minutes or more, and in which the cord was not tied until pulsation had stopped. Group B represents a group of 35 cases born by cephalic presentation, in which the duration of labor was less than 12 hours, in which the temperature dropped below 97 degrees, in which ether was given for less than 15 minutes, and in which the cord was tied before pulsation had stopped. The weight curves speak for themselves. Group A lost weight only during the first 24 hours, the maximum loss being 3.53 per cent. From this point they recovered rapidly. On the fifth day (end of fourth day) they had practically recovered their birth weight and on the eighth day, they were 1.76 per cent over birth weight. Group B lost much more during the first day, and continued to lose sharply during the second day, the maximum being 5.81 per cent. On the fifth day, they were still 4.47 per cent below birth weight, considerably more than Group A on the second day. On the eighth day, they were still 2.55 per cent below birth weight.

SUMMARY

1. A statistical analysis of 996 newborn babies is presented with the view of determining whether obstetrical and neonatal procedures influence weight loss in the newborn.

2. It is shown that certain factors tend definitely to increase the loss in weight and that others tend to decrease the loss.

3. It seems conclusive that the weight loss of the newborn is not entirely "physiologic."

4. The evidence presented tends to confirm the idea, that the "normal" newborn is in a state of mild shock as a result of the trauma of labor.

5. In general, factors which tend to retard or ease the second stage of labor seem to be favorable to the child.

EVALUATION OF THE INTRADERMAL TEST FOR PREGNANCY

SUSANNE R. PARSONS, M.D., F.A.C.S., Santa Barbara, California

THE report of Gilfillen and Gregg on a "new, rapid, and economical" test for pregnancy which appeared in September, 1936, has led some of us to attempt to repeat their work. It seems worth while at this time to collect the data presented in the reports of these other workers and to add thereto a small series of tests which I have carried out.

An ideal test for pregnancy must meet certain requirements. It must first and foremost be at least 95 per cent accurate. It should be rapid, economical, and so simple that it may be available to workers lacking elaborate laboratory facilities. The Aschheim-Zondek test meets the first but requires several days and a large and always available supply of animals. Its various modifications offer little improvement in these respects.

Gilfillen and Gregg report that the skin test for pregnancy meets all the above requirements and in their hands they found it "proved more delicate than the Aschheim-Zondek test in border cases." The test is based on the idea that an anterior pituitary-like substance is present in the circulation of pregnant women, therefore these women would not be sensitive to this substance injected intradermally. Non-pregnant women would show a reaction, as it would not be present in the blood stream. Their technique consists of the intradermal injection of 2 minims of antuitrin-S in the flexor surface of the forearm, after it has been cleansed with sterile water. The reaction occurs usually within a few minutes, or may be delayed as long as 2 to 3 hours in elderly women. An area of erythema, 7 to 40 millimeters in diameter about the site of injection, develops in non-pregnant patients. In pregnancy no reaction occurs. They used the test not only for pregnancy, but in gynecological conditions, as abortion, ectopic pregnancy, hydatidiform mole, and teratoma of the ovary. A series of 24 controls, known non-pregnant patients, confirmed the accuracy of their test, which they state to be reliable in all these conditions.

Although Gilfillen and Gregg make no mention of the fact, this test was neither new nor original with them. It was first used by Porges and Pollatschek and reported before the Society for Internal Medicine in Vienna, March, 1929. Prolan was used and the readings were made the following day. This report was enthusiastic and it was claimed to be reliable in all cases but one, a woman with a hypophyseal tumor. No statement was made as to the number of cases tested, however.

Alfred Deutsch repeated this work on a series of 45 pregnant and 65 non-pregnant women. He concludes that there is no essential difference in skin reaction between the pregnant and non-pregnant. Only 11 of a series of 65 non-pregnant women gave a strong reaction. Strauss (10) also ran a series of intradermal tests using non-pregnant and pregnant females, males, females at menopause, postpartum women, cases of ectopic pregnancy and of abortion, as well as menstruating women. He concludes the test "is neither definite nor reliable." He states that in a private communication Porges and Pollatschek verified his conclusions, after they had used the test more extensively in Vienna.

I decided to attempt to repeat the work of Gilfillen and Gregg, using the technique as described by them. Further, it seemed wise to check the results with other anterior pituitary-like substances, and for this follutein and antophysin were chosen. A fourth injection for control, of sterile water with a few drops of glycerine, was made. Our technique consisted in thorough cleansing of both forearms, flexor surfaces, with sterile water. Two minims of each solution, antophysin, antuitrin-S, follutein, and glycerine-water, were injected intradermally, and the reaction ob-

served at 15, 30, and, if no reaction had occurred by this time, again at 60 minutes. The solutions were made up freshly and kept on ice when not in use. A series of 140 women—100 known pregnant, 10 postpartum, and 30 known non-pregnant patients—were tested. Careful note was made of the ages of the patients, the duration of pregnancy, and the time of the interval before reaction occurred. In the control group the relation to menstruation was noted, and in the postpartum group, the days since delivery. Our results were as follows:

In 100 cases of known pregnancy, no reaction with any of the solutions was shown in 66, in which group 1 ectopic is included; of the 34 cases which showed reaction 30 reacted with follutein only, 4 with all three solutions. Thus we see that follutein failed in 34 per cent; antuitrin-S and antophysin in 4 per cent.

The possible influence of age was studied as follows. Of the total 100 patients, 29 were under 20 years of age, 56 were 21 to 30, 15 were 31 to 40. Of the 66 which showed no reaction, 18 were under 20, 38 were 21 to 30, and 10 were 31 to 40. Of the 30 reacting with follutein, 9 were under 20, 17 were 21 to 30, and 4 were 31 to 40. Of the 4 reacting to all three solutions 2 were under 20, 1 was 21 to 30, and 1 was 31 to 40. These figures fail to show any evidence of age influence.

Studying the reaction from the standpoint of duration of pregnancy, we have: 8 cases of pregnancy of 1 month's duration; 3 of 2 months; 8 of 3 months; 7 of 4 months; 7 of 5 months; 11 of 6 months; 18 of 7 months; 24 of 8 months; 12 of 9 months; 2 of 10 months.

In the 11 cases of 2 months' or less duration, 8 reacted to one or more solutions, so that only 3 correct reactions were given. There were 4 who reacted to follutein alone, and 4 who reacted to follutein, antuitrin-S, and antophysin, but not to the control. In the cases of 3 months' duration, 5 showed no reaction with any solution, and 3 reacted only to follutein. Thus we see in the first 2 months the test proved incorrect in 72 per cent with all solutions. Almost one-third error was shown in follutein alone and in follutein, antuitrin-S, and antophysin. As the duration of pregnancy increases, the percentage of error is reduced. The 3 month group showed that over 50 per cent gave positive pregnancy test.

The postpartum group gave the following results.

Number of cases	Days postpartum	Reaction
1	1	No reaction to 3 solutions
1	2	No reaction to 3 solutions
3	4	1 no reaction, 1 to follutein, 1 to antophysin
2	6	All reacted with follutein
1	9	No reaction to 3 solutions
2	10	All reacted to follutein only

Thirty controls of known non-pregnant women were used, the ages varied from 19 to 50. In 6 of these there was no reaction observed with any of the solutions, or 20 per cent positive pregnancy test in known non-pregnant individuals. In 15 there was a very faint reaction with follutein only. In 1 there was a definite reaction with follutein only. In 1 case both follutein and antuitrin-S gave a faint reaction. Seven cases gave a definite reaction with all three solutions, and no reaction with the control injection. The ages of the 6 patients with no reaction were 19, 20, 21, 25, 37, 50. The ages in 7 with definite reaction were 21, 38, 30, 38, 25, 36, 26. The ages of the first group average 28 years, that of the second, 30 years, which slight difference could be of little significance in the result of the test.

The relation to menstruation, in the group of 6 with no reaction was 25, 30, 19, 10, 20 days past onset of last period. This shows little essential difference in the two groups.

In all groups studied, the reaction occurred promptly within 15 minutes, and in no case was it observed to show up as late as 30 minutes after the injection was made.

DISCUSSION

The intradermal test, as shown by the foregoing figures, gives a very unreliable test for pregnancy, since it is inaccurate in both the control group and in the known pregnant group with an error of from 4 to 72 per cent. In the early months of pregnancy, when we particularly desire an accurate test, we find as high as 72 per cent error. Age, menstruation,

days postpartum, and duration of pregnancy have little influence on readings. Follutein was found to react more often both in the pregnant and non-pregnant groups, due perhaps to a protein reaction, rather than to the anterior pituitary-like hormone present.

Difficulty was experienced in making the readings, as pigmentation of the skin, and degrees of erythema were influencing factors, which often left me in doubt of the classification into which the test should fail. We have found this intradermal test thoroughly unreliable, and feel that it gives far too high a percentage of error for it to be trusted clinically. This is corroborated by the work of Strauss and Deutsch.

Gruskin reports the use of a placental extract which has been heated, with the result that the anterior pituitary-like gonadotropic fraction is destroyed. He claims good results.

In July, 1936, Schneider and Cohen report a series of 118 tests carried out on 95 females and 23 males. There were 21 pregnancies, 17 postpartum, or postabortal, 6 normal, and 74 with a wide variety of diagnoses. The results of the test showed 11 were not pregnant, 107 pregnant. Actually there were 21 pregnancies.

Isadore Gersh reports a series of 113 tests of which 50 were normal men and non-pregnant women; 48 were known cases of pregnancy of 2 or more months' duration and 15 were 1 to 9 days postpartum. In this series 3 injections were made, a control of normal saline with 0.5 phenol, antuitrin-S, and an anterior pituitary-like hormone extracted from placental tissue at the University of Colorado, Department of Pharmacology. The results of the tests show both false positive and false negative reactions. With antuitrin-S 20.8 per cent false negative results were obtained in the pregnant series and 6.6 per cent in the postpartum cases while 81.6 per cent of the men and 66.6 per cent of the non-pregnant women showed false positives. The control injection gave erythematous reactions in 8.8 per cent in 30 minutes and 5.4 per cent in 60 minutes.

Frank and Wahrsinger report a series of 198 cases. They used three different hormonal products, antuitrin-S[1], anterior pituitary luteum[2] and progestin[3]. With antuitrin-S 163 cases were tested and showed that of 112 definitely pregnant women 28 gave positive skin reactions (non-pregnant reaction). Eight gave doubtful and 76 no reaction. This gave a 68 per cent accuracy. There were 21 postpartum women, all of whom gave strongly positive reactions. The second hormone was used in only 6 pregnant patients, 2 gave positive, 3 negative, 1 doubtful skin reactions. The third hormone was used in 29 cases and 10 known pregnant patients gave 9 positive skin reactions and 1 doubtful. The result of the entire series of 198 cases shows that 98 per cent of cases including pregnant women gave a positive skin reaction (non-pregnant).

Table I shows the results of the several series of cases presented by workers other than Gilfillen and Gregg.

TABLE I

	Total cases	Known pregnant	Non-pregnant	Positive skin reaction (non-pregnant)
Deutsch	110		65	11
Schneider	118	21		11
Gersh	113	48		20.8%
Frank and Wahrsinger	198	112		28
Parsons	140	100		34
Total	679			

These results show little variation with the use of different preparations of the hormone. Among those which have been used were antuitrin-S an anterior pituitary-like hormone extracted from placental tissue[4], anterior pituitary luteum, progestin, antohphysin[5], follutein[6].

In conclusion, therefore, we may say the intradermal skin test, in 679 cases has proved entirely unreliable in the hands of all workers who have attempted to repeat the work of Gilfillen and Gregg. There seems to be no choice among the various hormonal preparations used; all yield equally unreliable results.

This work was done under a grant from the St. Francis Hospital Research Fund. The writer is indebted to the Santa Barbara General Hospital for generous use of material and also to the Nurses of St. Francis and Santa Barbara Cottage Hospitals for co-operation in making these tests.

[1]Parke, Davis and Co.

[2]Ayerst.
[3]Upjohn.
[4]University of Colorado.
[5]Winthrop.
[6]Squibb.

LITERATURE

1. DEUTSCH, ALFRED. Ueber die Verwendbarkeit der Schwangerschaftsprobe. Zentralbl. f. Gynaek., 1929, 53: 2920.
2. DOWELL, D. M. Preliminary observations on the menstrual cycle and pregnancy with a simple pregnancy diagnostic test. J. Missouri M. Ass., 1933, 30: 275–277.
3. Idem. J. Am. M. Ass., 1934, 103: 510.
4. FRANK, C. W., and WAHRSINGER, P. B. Skin tests for pregnancy. Am. J. Obst. & Gynec., 1938, 35: 303.
5. GERSH, ISADORE. Antuitrin-S cutaneous test for the diagnosis of pregnancy. Am. J. Obst. & Gynec., 1938, 35: 301.
6. GILFILLEN, G. C., and GREGG, W. K. A new, rapid, economical test for pregnancy and certain gynecologic conditions. Am. J. Obst. & Gynec., 1936, 32: 498–501.
7. GRUSKIN, BENJAMIN. An intradermal test for pregnancy. Am. J. Surg., 1936, 31: 59.
8. PORGES, OTTO, and POLLATSCHEK, R. J. Am. M. Ass., 1929, 93: 559.
9. SCHNEIDER, BERNARD, and COHEN, A. E. Nonspecificity of gonadotropic factor of pregnancy urine intradermally as a test for pregnancy. J. Am. M. Ass., 1937, 109: 115.
10. STRAUSS, HYMAN. The Porges and Pollatschek skin test for pregnancy. Am. J. Surg., 1930, 8: 1271.
11. Idem. J. Am. M. Ass., 1934, 103: 1015.

THE RÔLE OF TUBERCULOSIS IN ANAL FISTULA

LOUIS A. BUIE, M.D., NEWTON D. SMITH, M.D., and RAYMOND J. JACKMAN, M.D.,
Rochester, Minnesota

THIS study was undertaken in order to clarify, if possible, the controversy regarding tuberculosis as a cause of fistula-in-ano. Opinions have varied widely. Some believe that the majority of fistulas are of tuberculous origin; many feel that any relationship that may exist between anal fistula and tuberculosis is not significant. One probable reason why fistulas are considered to be of tuberculous origin is that healing often fails to occur following operation. Although a relationship between fistula-in-ano and phthisis was observed more than 2000 years ago, opinions then, as now, varied greatly. In early Roman literature (1) it was recorded that many patients who had anal fistula recovered promptly after operation but others did so slowly or not at all, and that many such patients died of "consumption." It was therefore believed that all fistulas drained infectious "humors" from the "system" and if closure were attempted disaster would result. Heurteloup actually advised the production of artificial fistulas in cases of consumption.

When we assumed our task, it appeared that there were five phases of the problem which required solution, namely: (1) What is a tuberculous anal fistula? (2) What percentage of anal fistulas are tuberculous? (3) In what percentage of cases of anal fistula is the tuberculous process a primary one? (4) What percentage of anal fistulas occurring among tuberculous patients are tuberculous? (5) If a tuberculous anal fistula is known to be present, should the treatment be altered?

Satisfactory answers are not available in the literature. The chief reason for the wide variation in opinions is that there is disagreement concerning what criteria are proper for the identification of a tuberculous anal fistula.

From the Section on Proctology, The Mayo Clinic, and The Division of Proctology, The Mayo Foundation. Abridgment of thesis submitted by Dr. Jackman to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Proctology.

REVIEW OF LITERATURE

A voluminous literature bears testimony to the difference of opinion on this subject. There are several reasons why the incidence of tuberculous anal fistula reported in the literature reviewed by us varies from 1.4 per cent to 61 per cent. Some studies were made in general hospitals; others were made in tuberculosis sanatoriums or in hospitals which had a special service for tuberculous patients. Often, histological or bacteriological study has not been made and systematic methods have not been used for diagnosis.

As to the frequency of pulmonary tuberculosis and co-existing anal fistula, figures quoted from various tuberculosis sanatoriums vary from 7 to 18 per cent. A wide variation is noted in the incidence of tuberculous fistula among patients who have pulmonary tuberculosis. Figures reported vary from 4 to 100 per cent.

What constitutes a tuberculous fistula and on what grounds are we justified in making a diagnosis? It is a discouraging task to attempt to correlate the findings of various investigators when the criteria on which the findings are based vary so greatly. There are two different methods which investigators have employed for determining a positive diagnosis: (1) that which depends on demonstration of the Mycobacterium tuberculosis by the inoculation of animals or by histological examination; (2) that which depends wholly on positive clinical findings. Between these two extremes are those who feel that demonstration of a certain histological picture is of diagnostic value. In addition to these factors, which partially account for the disparity in figures and diversity of opinion, is the difference in the material used for investigation. Attempts to demonstrate the tubercle bacillus in cultures made from the discharge of the ischiorectal abscess have met with little success.

Gabriel's work proved satisfactorily that inoculation of animals is the diagnostic

method which yields the most satisfactory results. He found that it is difficult to demonstrate tubercle bacilli in the tissues and he was unable to find the bacillus in any section prepared from tissue obtained from 6 patients who had been proved to have tuberculosis by the method of inoculation of animals. Moreover, in only 4 of the 75 cases which he studied did he find tubercle bacilli by using the staining method of Ziehl-Neelsen.

Tuberculous ulceration of the rectum does not occur frequently. In cases of fistula-in-ano, the tubercle bacillus gains entrance to the perianal tissues through a diseased crypt. The pathological characteristics of the tuberculous anal fistula are similar to those of tuberculosis elsewhere in the body excepting those changes which accompany secondary infection and trauma. Frequently, the attempt to make a clinical diagnosis or one based on the gross pathological characteristics of such a lesion is an error. The majority of such diagnoses are based on the appearance of the secondary, or external, openings. The appearance of the secondary opening may vary greatly, depending on the duration of the disease.

ROUTES OF INFECTION

In general, it is thought that there are four routes by which tubercle bacilli may gain access to the anorectal region.

Extension of infection from the lumen of the bowel. This is probably the usual route. The organisms gain entrance to the intestinal canal after they have been swallowed in the sputum. Tubercle bacilli, having passed through the digestive canal in this way, rarely produce tuberculosis in the anorectal region. Although tuberculosis of the intestine and rectum do occur and although tubercle bacilli are often found in feces, anorectal tuberculosis does not develop in the majority of the cases of pulmonary tuberculosis.

Transportation of organisms by the blood stream. According to this theory, tubercle bacilli are carried in the blood stream from some focus and are lodged in the submucous layer of the rectum and in the fat of the ischiorectal fossæ.

Direct external inoculation. Patients suffering from active pulmonary tuberculosis may contaminate the anus, especially if an abrasion is present. This may result in direct inoculation of the abrasion with Mycobacterium tuberculosis.

Direct extension. Tuberculosis of the female genital organs, of the prostate gland or the seminal vesicles may produce a fistula which has an external opening near the anus. Similarly, tuberculosis of the sacrum, coccyx, or pelvic bones may involve the perirectal tissues and produce fistulas similar to anal fistulas.

Anal fistulas originate from infected anal crypts and rarely is the primary opening of such a fistula found elsewhere. In only 2 of the cases presented in this report was there an associated condition which suggested the possibility that tubercle bacilli had gained access to the ischio-anal or ischiorectal tissues through avenues other than the crypts of Morgagni. Probably the most frequently offending organism in cases of ischiorectal abscess is the colon bacillus.

Is the Mycobacterium tuberculosis a primary or secondary invader? It seems reasonable to regard tuberculous ischiorectal conditions in the same light as tuberculous conditions of the thoracic wall. Primary tuberculous abscess of the thoracic wall is practically unknown.

METHOD OF STUDY

This investigation is based on 206 consecutive cases in which operation was performed for anal fistula. In addition to recording the patient's history and performing a physical examination, a roentgenological examination of the chest and routine laboratory tests of urine were carried out. Flocculation tests, determination of the concentration of hemoglobin, and of the number of erythrocytes and leucocytes also were performed. At the time of operation the surgeon paid particular attention to the selection of tissue that was to be subjected to examination and analysis.

Part of the selected tissue was prepared for inoculation into guinea-pigs in the following manner. The tissue was finely divided by grinding and mixing with sand in a mortar. With this 5 cubic centimeters of normal saline solution was thoroughly mixed. The supernatant fluid was poured off and centrifuged for one hour at 2500 revolutions per minute in

a No. 2 centrifuge with a head radius of 13.5 centimeters. Then the fluid was poured off and discarded and a portion of the sediment was removed, stained by methods for revealing acid-fast bacilli and studied for the presence of free tubercle bacilli. The remainder of the sediment was re-emulsified in 5 cubic centimeters of a normal saline solution. This product was placed in a refrigerator for 4 to 7 days to attenuate the colon bacillus, which is much more lethal to the guinea-pig than the staphylococcus or streptococcus. The colon bacillus also is the cause of the high proportion of failures in inoculating guinea-pigs with material taken from the lower portion of the gastro-intestinal tract.

Two guinea-pigs were given injections of material obtained from each patient, one animal being inoculated subcutaneously and the other intraperitoneally. If the guinea-pigs died and gross lesions were not evident before 3 weeks had passed, the test was considered a failure; if a guinea-pig died and lesions were not present after 3 or more weeks had elapsed, the result of the test was considered negative. If both animals were alive at the end of 4 weeks, the one receiving the intraperitoneal injection was tested by injecting 0.5 cubic centimeter of old tuberculin (O.T.) subcutaneously. If that guinea-pig died and the results of the test were positive, its mate was killed and examined. All other guinea-pigs were permitted to live for 8 weeks and, at the end of that time, were killed; and the result of the test was considered either positive or negative depending on whether lesions were present or absent.

Magath (5) has shown the importance of balancing the subcutaneously and intraperitoneally injected animals against each other. He pointed out that it is easy to understand why intraperitoneal injections should end fatally more often than subcutaneous injections, because much of the material injected contains pyogenic organisms; but, why this is true when equal amounts of the material are injected into each animal is not clear. Magath has also shown that tuberculin, although not productive of immediate death of each animal in which a positive result has been obtained, clearly shortens the time necessary for the development of tuberculosis by about 3 weeks. In addition, Magath and Feldman (6) have demonstrated that more specimens will be found to contain the bacillus of tuberculosis by the method of injecting material into guinea-pigs than by the method of culturing the organism.

The possibility of obtaining false positive results from the inoculation of guinea-pigs may arise owing to spontaneous development of tuberculosis. Magath and Feldman have shown that when guinea-pigs are kept in cages in a room isolated from tuberculous animals and when they do not receive food from the tables of tuberculous patients and are cared for by non-tuberculous caretakers, the chances of their contracting tuberculosis is so slight that it may be ignored. Any such animal, if in normal health, may be considered suitable for experiments such as ours.

Some authors have questioned the reliability of results obtained by inoculation of guinea-pigs. Magath and Feldman stated that animals living 8 weeks after inoculation, in which gross lesions of tuberculosis have failed to develop, probably do not have tuberculosis and that the histological examination of such tissue is not necessary as a routine procedure. They concluded, after a careful study, that inoculation of guinea-pigs is a reliable means of proving the tuberculous nature of clinical material.

Fansler has expressed doubt as to the reliability of such a method when there is a focus of tuberculosis elsewhere in the body of the patient. In our series, we have avoided such error by performing repeated examinations of the sputum obtained from the patient and have compared the results of the inoculation of the guinea-pig with those of histological study. A piece of tissue almost invariably derived from the same specimen as that used for inoculation of animals was sent to the laboratory where routine pathological and histological studies were carried out.

In those cases in which the results of inoculation of animals were positive and those of routine histological study were negative, subsequent microscopic studies were made of sections cut from numerous blocks of tissue in

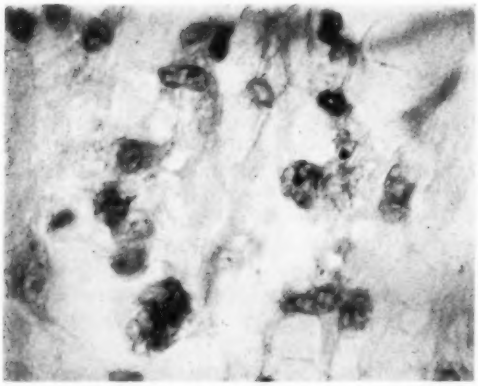


Fig. 1. Tubercle bacillus in tissue adjacent to fistulous tract. ×97.

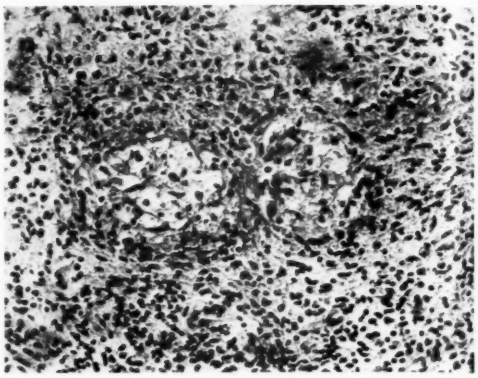


Fig. 2. Tubercles containing epithelioid cells, surrounded by a zone of lymphocytic infiltration. ×90.

an effort to compare the results of histological study with those of inoculation of animals.

The staining technique of Ziehl-Neelsen was used on sections of tissue in all cases in which the result of inoculation of the animal was positive.

RESULTS

In this study of 206 consecutive cases of anorectal fistula (Table I) there were 11 (5.3 per cent) in which both the animals that received subcutaneous injections and those that received intraperitoneal injections died before the aforementioned time limit had expired. This low percentage of failures can probably be accounted for by the fact that a method of attenuation of the colon bacillus was employed. More deaths occurred before the time limit expired in the cases of those guinea-pigs injected intraperitoneally than occurred after the time limit had expired. However, as Magath has previously pointed out, a larger number of positive results are to be expected from the intraperitoneal method of injection than from the subcutaneous method of injection.

One hundred and ninety-five cases (94.7 per cent of the total group) were studied successfully and completely. Of these, evidence of the presence of tuberculosis was not found in 163 cases (83.6 per cent). In 32 cases (16.4 per cent), we were able to find evidence of the presence of tuberculosis somewhere in the body.

Of this group of 32 cases, 10 (5.1 per cent of total cases) gave evidence of a tuberculous "focus," that is, 7 of the patients had healed or inactive pulmonary tuberculosis; 2 had an active pulmonary lesion and 1 had tuberculosis of the cervical lymph nodes. Inoculation of animals, routine histopathological studies and subsequent study of numerous sections of tissue did not reveal evidence of tuberculosis in the anorectal fistula.

Inoculation of animals gave positive results in 22 cases (11.3 per cent of those successfully studied) whereas routine histological study of sections from an adjacent piece of fistulous tissue gave positive results in only 8 cases (4.1 per cent). These results approach closely those of other investigators who have used the same method of studying sections of a similar nature. If we had relied on routine histopathological study only, we would have missed the diagnosis in 63.6 per cent of the cases. In a subsequent study of numerous sections of tissue derived from those cases in which the diagnosis based on the results of inoculation of animals did not coincide with that based on routine histopathological examination, we were able to demonstrate the presence of the tubercle in 5 additional cases (Figs. 1 and 2). There were, therefore, 13 cases (6.6 per cent of total cases) in which the results of inoculation of animals coincided with those of microscopic study, whereas in the remaining 9 cases (41.8 per cent of positive results) evidence of

TABLE I.—SUMMARY OF A STUDY OF ANORECTAL FISTULA WITH REGARD TO ITS TUBERCULOUS NATURE—206 CONSECUTIVE CASES

	Cases	Per cent of cases successfully studied	Per cent total positive animal inoculations
Inoculation failed	11*		
Successfully studied	195†		
Negative in all respects for tuberculosis	163	83.6	
Evidence of tuberculosis somewhere in body	32	16.4	
Evidence of tuberculous "focus" but inoculation and histopathological examination negative	10	5.1	
Animal inoculation positive	22	11.3	
Organism demonstrated by Ziehl-Neelsen stain	3	1.5	13.6
Evidence of tuberculous "focus"			
Positive	17	8.7	77.3
Negative	5	2.5	22.7
Histopathological examination			
Routine positive	8	4.1	
Subsequent positive	5	2.5	22.7
Subsequent negative	9	4.6	41.8

*5.3% of total cases. †94.7% of total cases.

tuberculosis could not be found microscopically. Frequently, foreign body giant cells are found in sections of tissue from anorectal fistulas and are sometimes confused with anatomic tubercle.

Ziehl-Neelsen staining technique was carried out on sections of tissue derived from all cases in which the result of inoculation of animals was positive and the bacillus of tuberculosis was identified in 3 cases (1.5 per cent of the total group or 13.6 per cent of the cases in which positive results were obtained on inoculation of animals).

Of the 22 patients who were proved to have a tuberculous fistula, 17 (8.7 per cent of those successfully studied and 77.3 per cent of those in which positive results were obtained by inoculation of animals) were shown to have, in addition, a so called focus of tuberculosis elsewhere in the body (9 cases of active pulmonary tuberculosis and 8 cases of a healed lesion in the lungs). In the 5 remaining cases of tuberculous fistula (2.5 per cent of those successfully studied and 22.7 per cent of those in which positive results were obtained by inoculation of animals), evidence of a "focus" of tuberculosis could not be found. In 1 of the 5 cases the organism was demonstrated in sections of tissue taken from the fistula.

Healing of the wound in cases of surgically treated tuberculous fistula is definitely prolonged. In the 22 cases in which positive results were obtained, the average time required for healing was 73 days as compared with an average of 29 days in the 173 cases of non-tuberculous fistula. Whether a fistula is tuberculous or not should not alter the type of treatment employed.

CONCLUSIONS

1. Inoculation of animals by the method described is the most accurate way of determining the tuberculous or non-tuberculous nature of an anorectal fistula.

2. In this series, positive results were obtained in 11.3 per cent of cases. Routine and also subsequent microscopic study of many sections of tissue proved that tuberculosis was present in only 6.6 per cent of the cases.

3. A tuberculous focus was present in 77.3 per cent of the cases of tuberculous fistula.

4. If pulmonary tuberculosis and anorectal fistula co-exist, the tuberculous nature of the fistula can be strongly suspected.

5. The co-existence of a focus of tuberculosis and non-tuberculous fistula occurred in 5.1 per cent of this series of cases.

6. Healing of the wound after operation is slower in cases of tuberculous fistulas than it is in those cases of non-tuberculous fistulas but healing should always be complete if the operation has been performed properly and if the wound has been dealt with adequately.

REFERENCES

1. BUIE, L. A. Ancient and modern knowledge concerning anal fistula. Med. Ann. Dist. Columbia, 1936,5: 123.
2. FANSLER, W. A. The relationship of tuberculosis to fistula in ano. J. Am. M. Ass., 1925, 85: 671–673.
3. GABRIEL, W. B. Results of an experimental and histological investigation into seventy-five cases of rectal fistulæ. pp. 154–161. Collected Papers of St. Mark's Hospital. London: H. K. Lewis & Co., Ltd., 1935.
4. HEURTELOUP. Quoted by Freeman, Leonard. In Klebs, A. C. Tuberculosis. p. 768. New York: D. Appleton & Co., 1909.
5. MAGATH, T. B. Large doses of tuberculin in testing guinea pigs inoculated for diagnostic purposes. Am. J. M. Sc., 1934, 188: 403–409.
6. MAGATH, T. B., and FELDMAN, W. H. The relative value of cultural methods and guinea pig inoculation in the diagnosis of tuberculosis. Am. J. Clin. Path., (May) 1932, 2: 199–228.

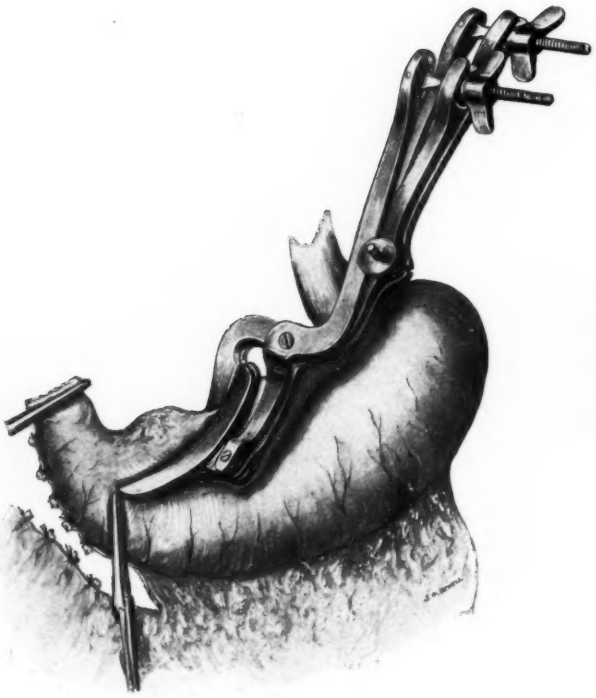


Fig. 1. Method of applying the author's crushing clamp. The duodenum has been divided between clamps, and the crushing clamp and a Schoemaker colectomy forceps are applied to the stomach. Note: Considerably more of the stomach is usually removed than this illustration depicts.

Fig. 2. One blade of the crushing clamp has been removed and the continuous hemostatic suture along the new lesser curvature is being inserted.

A Modified Schoemaker Gastrectomy for Chronic Gastric Ulcer.—John Morley.

CLINICAL SURGERY

FROM THE MANCHESTER ROYAL INFIRMARY

A MODIFIED SCHOEMAKER GASTRECTOMY FOR CHRONIC GASTRIC ULCER

JOHN MORLEY, Ch.M., F.R.C.S., Manchester, England

IN 1921, J. Schoemaker of the Hague described in SURGERY, GYNECOLOGY AND OBSTETRICS a modification of the original Billroth I gastrectomy that appeared to the present writer to obviate most of the difficulties and dangers of that operation.

After an extended trial of Schoemaker's operation it was realized that his original two bladed crushing clamp was often difficult to apply and prone to slip off the stomach when it had been applied, and in consequence a clamp of different type, that could be applied from the upper or lesser curvature aspect of the stomach, was designed for me by Dr. K. B. Pinson, anesthetist to the Manchester Royal Infirmary.

The operation now to be described has been found to be superior to the Pólya-Balfour gastrectomy in cases of chronic gastric ulcer in that it is less likely to be followed by severe anemia, since some gastric function is preserved, while it involves no greater risk of anastomotic ulcer. In cases of duodenal ulcer with pronounced hyperchlorhydria, or in gastrojejunal ulcer, the more destructive Pólya-Balfour operation is preferred.

PREPARATION FOR OPERATION

The first essential is to see that dental sepsis is eradicated, and that the patient is provided with an efficient supply of teeth, natural or artificial, for the purpose of mastication.

When the roentgenographic examination shows appreciable delay in emptying, as is so commonly found in large prepyloric ulcers, gastric lavage for a few days, repeated on the morning of operation, is advisable. In cases of marked anemia from gross or continued occult hemorrhage, an intensive pre-operative course of iron is essential.

THE ANESTHETIC

While some surgeons are strong advocates of a combination of local and splanchnic anesthesia, we have found that basal anesthesia with avertin, followed by gas and oxygen with some ether, is less trying to the patient and the surgeon, less time-consuming, and no more dangerous as regards postoperative complications. The services of a really expert anesthetist are, of course, essential.

THE OPERATION

A right paramedian incision extending from the costal margin to a little below the umbilicus, is usually preferred, as it gives a stronger scar and affords the best access to the duodenum. The edges of the wound are then protected by gauze swabs. After a general inspection of the abdominal viscera, including the stomach and duodenum, the thin lesser omentum is torn through above the prepyloric portion of the stomach and a hand is inserted into the lesser sac of the peritoneum to separate the filmy congenital adhesions so constantly found between the stomach and the transverse mesocolon or colon. The pyloric vessels immediately above the first part of the duodenum are then clamped between two artery forceps, divided and ligatured with linen thread. The gastrocolic ligament is next divided between forceps, beginning just below the pylorus and working as far to the left as the point at which it is decided to divide the stomach. All the lower divided vessels are then tied, those on the upper or gastric side being left in the grip of the artery forceps. The line of this division may be carried immediately below the greater curvature of the stomach and above the gastro-epiploic vessels, or between the gastro-epiploic vessels and the transverse colon, in which case the right gastro-epiploic artery is divided below the pyloric antrum. While the former method has the theoretical advantage that it preserves the blood supply of the dependent portion of the omentum, it involves the ligature of many more vessels than the latter. We prefer to divide the omentum below the gastro-epiploic vessels on this account and have found no ill effects upon the omentum in practice. The

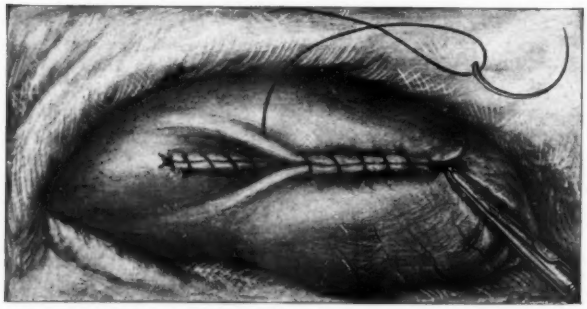


Fig. 3. Application of the invaginating seromuscular suture along the new lesser curvature.

left gastro-epiploic vessels are clamped, divided, and tied at a point as far to the left as is necessary. The next step is the division of the first part of the duodenum. Two Schoemaker colectomy clamps with grooved blades are applied side by side across the duodenum immediately distal to the pyloric sphincter, and the duodenum is divided between them with a knife. The cut ends of the duodenum held by the two clamps are cleaned with moist swabs. The distal clamp is left covered by a large gauze swab, and the proximal clamp is protected by a small gauze swab clamped over it by two Lane's tissue forceps. These forceps not only prevent any risk that the Schoemaker clamp may slip, but are convenient in exerting traction on the stomach.

The stomach is now lifted up and to the left, and any adhesions between the ulcer and the pancreas are divided. When the ulcer is not penetrating the pancreas this division is carried out with the knife. In large ulcers that have invaded the pancreas deeply, however, it is unsafe to cut into the pancreas, on account of the risk of subsequent leakage of pancreatic juice. In such cases the edges of the ulcer are stripped off the pancreas with the fingers, regardless of the fact that the lumen of the stomach is opened. Swabs are placed round before this maneuver, and a sucker is inserted into the stomach to empty it of any fluid contents. The line of cleavage where the ulcer is stripped off the pancreas is avascular and does not bleed.

Having freed the ulcer from its posterior adhesions, the left gastric (coronary) artery in the gastrohepatic omentum is divided between clamps. This is done a short distance above the ulcer on the lesser curvature. A hole is made between the lesser curvature of the stomach and the lesser omentum, and three curved artery forceps are applied to the upper part of the lesser omentum through this hole, so as to grasp the left gastric artery. The omentum and artery are divided by curved scissors, two of the artery forceps being left on the proximal part of the artery and one on the distal part. The proximal end is then doubly ligatured with No. 60 linen thread, and the distal end is also tied.

The stomach is now drawn downward and out of the wound, and the point on the greater curvature destined for anastomosis with the duodenum is determined. Here a Schoemaker colectomy clamp is applied at a right angle to the greater curvature, with care to include as much of the transverse section of the stomach in its grip as will correspond with the width of the duodenum.

While an assistant draws the stomach firmly downward, and also exerts some downward traction on the colectomy clamp that grasps the greater curvature of the stomach, the curved Pinson crushing clamp is applied to the stomach from the lesser curvature above the ulcer a little obliquely so that the tip of its blades touches the tip of the small colectomy clamp (Fig. 1). A straight or curved gastro-enterostomy clamp is now placed across the stomach distal to these two clamps to prevent escape of contents and the stomach is divided with a knife flush with the two proximal clamps, and its distal portion is removed.

The next step is closure of that part of the stomach in the grip of the large two bladed crushing clamp, to form what is to be the new lower portion of the lesser curvature. The outer blade of the crushing clamp is removed, leaving a frill of crushed stomach wall projecting from the inner blade. This stomach wall is sutured with a continuous stitch of No. 00 catgut (20 day), starting at the tip of the blade and working up to the lesser curvature (Fig. 2). The second blade of the

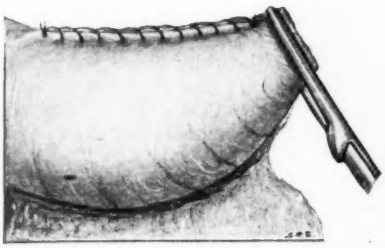


Fig. 4. The new lesser curvature on completion of the suture, viewed from behind.

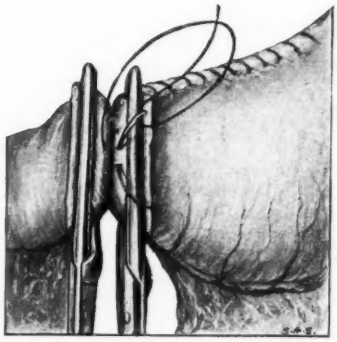


Fig. 5. End-to-end union of stomach and duodenum; commencement of posterior row of sutures.

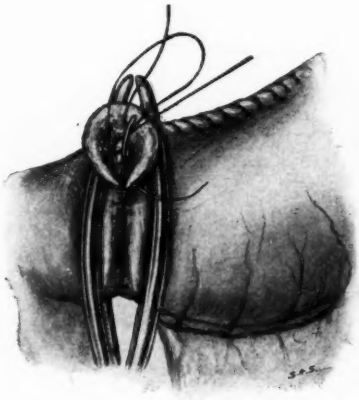


Fig. 7. End-to-end union of stomach and duodenum; hemostatic suture is shown nearing completion. For the sake of clearness the uncompleted seromuscular suture is not shown.

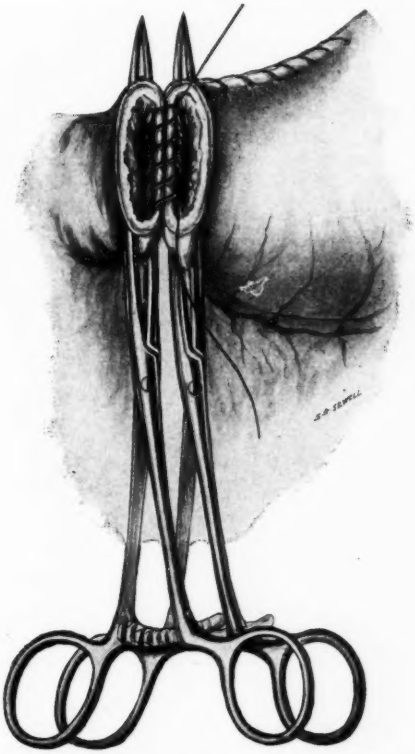


Fig. 6. End-to-end union of stomach and duodenum; commencement of continuous hemostatic suture. For the sake of clearness the posterior half of the seromuscular suture is not shown.

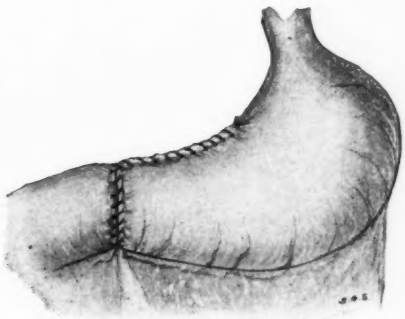


Fig. 8. The operation completed. Note the normal form of the stomach.

clamp is now removed, and a continuous seromuscular suture of catgut is inserted, so as to invaginate the former or through-and-through suture (Figs. 3 and 4).

The two small colectomy clamps, one on the duodenum and one on the greater curvature of the stomach, can now be approximated with the greatest of ease for the end-to-end anastomosis of the stomach with the duodenum. The posterior part of the continuous seromuscular catgut stitch is begun at the lesser curvature aspect. A curved needle is used, and it is inserted parallel with the clamps (Fig. 5). When the greater curvature is reached, the suture is knotted and laid aside.

Before the colectomy clamps occluding the stomach and duodenum are removed, these organs are secured by two gastro-enterostomy clamps placed one inch above and below the line of anastomosis. The occluding clamps are now removed, and the continuous through-and-through catgut suture is inserted, again on a curved needle (Figs. 6 and 7).

The seromuscular suture is next completed by carrying it along the anterior surface of the suture line up to the point at the lesser curvature where it started. After the circle is completed and the suture is tied, two further sutures are inserted to guard the "dangerous angle" on the lesser curvature from tension. We have never known leakage to occur at this or any other point.

In performing this end-to-end anastomosis it is important to make sure that no stenosis results. The finger and thumb should be able to meet readily when invaginating the anastomosis from without at completion of the operation (Fig. 8).

One point in the application of the crushing clamp requires emphasis. The clamp should never be applied too obliquely, so as to make the new prepyloric portion of the stomach too slender and funnel-shaped. In earlier cases in which this was done, some disturbing postoperative vomiting occurred for the first few days. When the clamp is applied, as it should be, almost transversely to the stomach, the postoperative course is usually free from vomiting. The abdominal wound is closed in layers in the usual way and a dressing applied.

POSTOPERATIVE TREATMENT

Morphia and atropine and rectal saline infusions are given for the first 24 hours. Intravenous saline by the continuous drip method is reserved for cases suffering from pre-operative anemia, or for those rare patients who develop symptoms of postoperative shock. Fluids sufficient to allay thirst are allowed from the first. A daily enema is given from the second day until the end of the first week. No solid food is allowed until a week from the operation has elapsed. The postoperative course is usually smoother than that after a simple gastro-enterostomy in that there is less tendency to vomiting.

MORTALITY RATE

In a consecutive series of 190 cases of Schoemaker gastrectomy for chronic gastric ulcer in which patients were operated upon by the writer, there have been 5 deaths, a mortality of 2.6 per cent. This is little above the mortality of gastro-enterostomy for simple ulcer, and compares favorably with the mortality of the Balfour-Pólya operation in the same type of case, which has been 6.4 per cent in my hands.

I am indebted to the publishers of the *British Journal of Surgery* for the loan of the illustrations. These drawings were reproduced to appear in an article on "The Technique and Results of Partial Gastrectomy for Chronic Gastric Ulcer." 1928, 16: 239–252.

SUPRACONDYLAR FRACTURE OF THE HUMERUS

An Analysis of 330 Cases

IRWIN E. SIRIS, M.D., Brooklyn, New York

THE purpose of this paper is the review of the results of treatment of 330 cases of supracondylar fractures of the humerus which have been seen on the Children's Surgical Service of Bellevue Hospital during the past 18 years. The 109 cases of supracondylar fracture that were reported in 1925 (8) are included in this report. Certain fundamental problems presented themselves in the management of these cases which will be discussed in this paper. A method of reduction and fixation is described so as to prevent deviation of the axis of the forearm. It is not the purpose to review the literature of supracondylar fracture but rather to present the salient clinical problems which have been encountered in the treatment of these cases.

Supracondylar fracture is a distinct entity having little in common with fractures in other parts of the body. This is particularly so for the following reasons: first, because of the close proximity of the fracture to the intricate articular surface of the elbow joint; second, the effect that the displacement of the fragments may have on the neurovascular structures passing over the joint; third, the possible permanent deviation of the axis of the forearm that may result from (a) an injury to the cartilage plate of one of the epiphysis, or (b) a failure to obtain a correct alinement of the distal fragment of a supracondylar fracture.

END-RESULTS

Of the 330 cases of supracondylar fractures treated, 292 (89 per cent) of the patients were followed from 2 months to as long as 14 years, and 38 were lost.

The factors which were considered in evaluating the results, are (1) restoration of function, (2) deformity, and (3) residual complications.

1. Restoration of function. Of the 292 cases, 236 (81 per cent) had almost complete restoration of function. Of the 56 remaining cases (19 per cent), 4, complicated by threatened ischemic paralysis, have not regained complete function, and in 52 others (18 per cent) the functional recovery is protracted and the patients are under treatment.

2. Deformity. There were 44 of the 236 cases which regained function, and in these cases there was deviation of the axis of the forearm, 26 having a loss in the carrying angle, 8 with a glaring *gunstock deformity*. In 2 cases the deformity has been corrected by a cuneiform osteotomy. Nineteen fractures healed with a perceptible increase in the outward angulation of the forearm. It is significant that the reparative process in children due to growth often corrects a deformity caused by a vicious union but does not always restore the normal carrying angle. In this series vicious union rarely permanently impaired function, while an unreduced lateral or mesial fracture or rotation of the distal fragment invariably altered the carrying angle.

3. Residual complications. There were 20 cases of muscular spasm and 7 of myositis ossificans. Both of these complications followed fractures about the elbow which were recorded in my previous paper. In the case of the 221 patients with supracondylar fracture which have been treated since 1924, when the former series was reported, there has been no case of either muscular spasm or myositis ossificans. In but 1 of the 9 cases which showed evidence of an impending Volkmann's ischemic paralysis did ischemia develop. Seven children had symptoms referable to injury of the deep muscular branch of the radial nerve and 4 of the ulnar nerve. Whether this resulted from a displaced fragment or excessive callus formation accompanying vicious union is uncertain, but it is interesting to note that the symptoms in all of these cases of nerve injury have disappeared as a result of the absorption of the excessive callus. No case of delayed ulnar neuritis has come under our observation as yet in this series.

The following classification has been adhered to in the analysis of the end-results:

Excellent—Complete function with a normal carrying angle.
Good —Complete function with a slight increase in the carrying angle.
Fair —Complete function with a 5 per cent loss of carrying angle.
—Limitation of less than 25 per cent flexion with a straight or normal axis of the forearm.

From the Children's Surgical Service, Bellevue Hospital, Fenwick Beekman, M.D., in charge.

Fig. 1. Typical supracondylar deformity with posterior displacement of the distal fragment.

Poor —Complete function and an obvious gun stock deformity.
—Limitation of less than 25 per cent extension and flexion of the elbow.
Bad —More than 25 per cent limitation of function.
—Volkmann's ischemic paralysis.
—Ankylosis.

Of the 292 cases followed, in 168 (58 per cent) the results can be said to be excellent: 30 (10 per cent), good; 69 (24 per cent), fair; 15 (5 per cent), poor; and 10 (3 per cent), bad. These results include the 52 cases (18 per cent) in which patients are under treatment, and in many of them there will be improvement in function and the cases therefore deserve better classification.

AGE INCIDENCE

It is significant that the largest number of cases occurred during the sixth year and that between the ages of 5 and 7, there were 162 (49 per cent). This being almost equal to the combined number of fractures occurring in the 9 remaining age groups of this series. The incidence of frequency in the various age groups appears to decrease both toward earlier childhood and the advancing years.

CLINICAL EXAMINATION

Of the 258 supracondylar fractures with displacement, the distortion from swelling increased perceptibly in proportion to the delay supervening between the time of injury and that of reduction (Fig. 1). In many of these the lower end of the anteriorly displaced upper fragment could readily be palpated beneath the skin. The break in the continuity of the humerus could often be palpated posteriorly. Due to this displacement and the extravasation of blood in the antecubital space, there was often much tension of the overlying skin which at times was followed by the formation of blebs. In most of the cases the forearm assumed a position of complete pronation with approximately 140 degrees of extension at the elbow joint. When the fragments were completely displaced there was always an increase in the anterior posterior diameter of the arm.

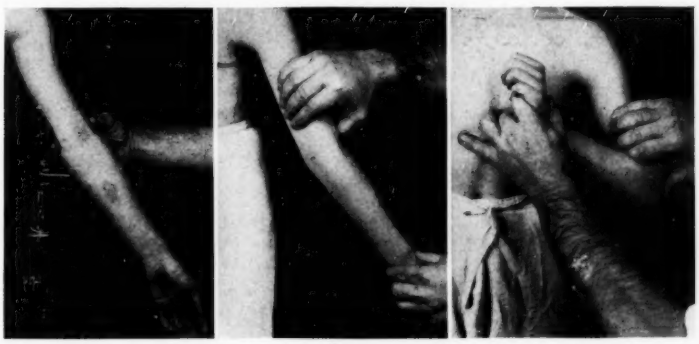
When there was overriding, measurements taken from the tip of the acromial process to the lateral epicondyle revealed an appreciable shortening as compared with the other arm. In none of these cases was there any disturbance in the relation between the three bony prominences of the elbow; this finding was indispensable in eliminating a posterior dislocation of the radius and ulna. The *presence or absence of neurovascular injury should be noted before any attempt is made to reduce the fracture so as to obviate a later question of such complications having resulted from the manipulation.* There were 12 compound fractures in this series, which are detailed elsewhere.

ROENTGENOGRAPHIC EXAMINATION

Roentgenographic examination should determine not only the extent of the displacement of the lower fragment but also whether there is an extension of the fracture line through the epiphyseal cartilage plate of either of the condyles. The amount of serration or spurring of the fracture surface should be noted, because of its influence upon attempts at reduction.

What at first appearance may seem to be a transverse fracture will occasionally be found to be a fracture line which extends obliquely downward and forward. This is the type of fracture that is so difficult to maintain in position after reduction. It is important to note the amount of lateral or mesial displacement of the lower fragment, as failure to recognize and correct this displacement will result in a varus or valgus deformity.

A lateral view will reveal the amount of anterior displacement of the upper fragment. The relationship of the distal fragment and the forearm which are one, to the upper fragment in regard to the amount of rotation of the lower fragment, is often demonstrable in this view. The significance of the rotation of the lower fragment on the upper is appreciated after the posterior displacement has been reduced when the upper



a b c

Fig. 2. a, b, c, Steps in procedure for reducing the lateral or mesial and posterior displacement of the distal fragment.

fragment can still be seen to project obliquely forward.

The stripping of the periosteum from the distal end of the upper fragment can be demonstrated by means of a lateral view as early as the seventh day after the fracture in practically every case in which the fracture has not been completely reduced. Ordinarily the stripped periosteum which is firmly attached to the displaced lower fragment is not visualized, for only after the deposition of calcium in the callus can the new shaft be discerned within the confines of the stripped periosteum.

DISPLACEMENT OF FRAGMENTS

Supracondylar fracture continues to be the most frequently encountered elbow injury on the Children's Surgical Service at Bellevue Hospital. In all the cases in which the distal fragment was displaced posteriorly, the trauma producing the injury was from a fall on the outstretched hand. The displacement resulted in a stripping of the periosteum from the distal end of the proximal fragment due to its firm attachment to the distal fragment. This was first noted by Poland in 1898, who drew attention to it as an important factor in the production of callus. This stripping of the periosteum plays an important part in limiting the displacement of the fragment and in subsequent healing, particularly when complete reduction has not been obtained. This may be demonstrated in 3 to 6 weeks' time by means of a roentgenogram, which then shows evidence of new bone springing from the displaced lower fragment and along the reflected periosteum.

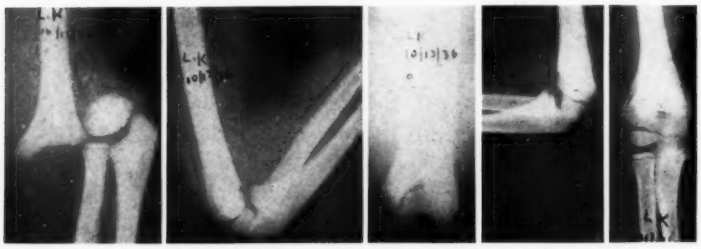
In 72 cases (22 per cent) there was no displacement of the lower fragment. Of the 244 cases (74 per cent), in which complete *posterior* displacement of the lower fragment was present, 162 had no appreciable lateral or mesial displacement, in 44 the lower fragment was displaced backward and inward and in 38 backward and outward. The lower fragment was displaced *anteriorly* in but 14 cases (4 per cent) all of which fractures were sustained through direct violence.

There were 232 fractures in which the line of fracture was transverse and 98 in which it was oblique. With the few exceptions in the case of oblique fractures the distal end of the proximal fragment was displaced into the antecubital space. Of the 330 fractures 33 were comminuted. Thirty-two extended into the external condyle, 39 into the internal condyle, and 21 through one of the epiphyseal cartilage plates.

In two of the comminuted fractures the articular fragment was split, a consequence of muscle contraction which forces the upper fragment between the lower fragments, thus distorting the elbow joint.

TREATMENT

There are four important objectives to bear in mind in the treatment of a supracondylar fracture. First and foremost is the prevention of a Volkmann's paralysis; second, a satisfactory reduction; third, the prevention of a varus or valgus deformity; and fourth, the restoration of function. All four objectives are dependent on obtaining a good alinement of the fragments. Permitting the malposition of the fragments to remain until the swelling has subsided is unreasonable. Such a procedure necessitates a difficult and prolonged course of treatment and a defeat in one or more of the objectives. The malposition should



a b c d e

Fig. 3. L. K. 9 years old, admitted to hospital October 2, 1936, with a, supracondylar fracture of the humerus; the proximal fragment is rotated obliquely forward and the distal fragment is displaced backward. b and c, With the aid of a fluoroscope and an anesthetic the fragments were satisfactorily reduced. Within 2 months function of the elbow was completely regained with a normal carrying angle. d and e, Roentgenographic examination April 17, 1937, shows normal outline of the shaft of the humerus with some periosteal stripping.

be corrected as soon as the roentgenographic examination has been interpreted. If the upper fragment is allowed to remain displaced in the antecubital space, and thus press upon and displace the neurovascular structures damage to these may result and produce a Volkmann's ischemic paralysis or nerve injury. If reduction is deferred difficulty in manipulation increases, because of the contraction of muscles and the organization of extravasated blood.

A significant relationship exists between the character of the line of fracture and the reduction. A serrated transverse fracture, properly reduced, will remain in alinement if immobilized with the forearm flexed beyond a right angle irrespective of the amount of supination or pronation. An oblique fracture line with an anteriorly displaced upper fragment presents a serious problem, as the displacement frequently recurs after reduction because of the lack of serrations on the fracture surfaces which permits an upward and backward displacement of the lower fragment unless there is proper immobilization.

a b c d

Fig. 4. L.C. a and b, Typical posterior displacement and rotation of the lower fragment. c, Correction of rotation and mesial displacement of lower fragment. d, Partial correction of posterior displacement, periosteal stripping and new shaft in process of formation.

Immobilization in acute flexion with pronation of the forearm, as recommended by Boehler, relaxes the pronator flexor group of muscles and lessens the possibility of a recurrence of the displacement. Recognition of the important part that the lateral or mesial displacement of the upper fragment plays in the ultimate result merits the attention of a member of the visiting staff in the care of the patient.

Although the utilization of any of the recognized procedures for reduction and immobilization may eventually result in a satisfactory anatomical and functional recovery, the *main objective* to be wished for *is the restoration* of an *anatomical alinement* by means of the *simplest procedure which will preclude any possible complication* and *restore a normal functioning elbow without deformity*.

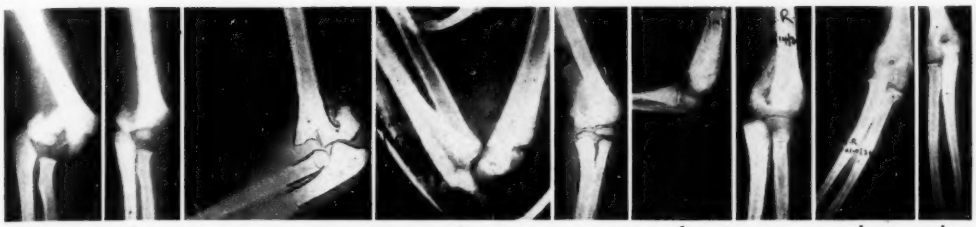
Anesthesia. The use of a general anesthetic is preferable in the reductions of supracondylar fractures as the patients should be completely relaxed before manipulation is begun. Exceptionally, a local anesthesia is warranted but only when a general anesthesia is contra-indicated.[1]

The fluoroscope. Formerly the fluoroscope was used throughout the entire manipulative procedure of reduction. Now because of the handicap of using leaden gloves and because of the danger of too long an exposure to the roentgen rays the fluoroscope is used only intermittently to verify the position of the fragments. Unfortunate x-ray burns occurred in 2 of our cases from the prolonged use of the fluoroscope.

[1]Introduction of 20 cubic centimeters of a 1% solution of novocain is made to the side of the vessels using the ridge of the lower end of the upper fragment as a guide for insertion of a large needle into the hematoma. Posteriorly a similar amount of solution is introduced above the ridge of the lower fragment and within the confines of the periosteum. No less than 10 minutes should elapse before the reduction is attempted.

a b c d e f

Fig. 5.



a b c d e f g h i

Fig. 6.

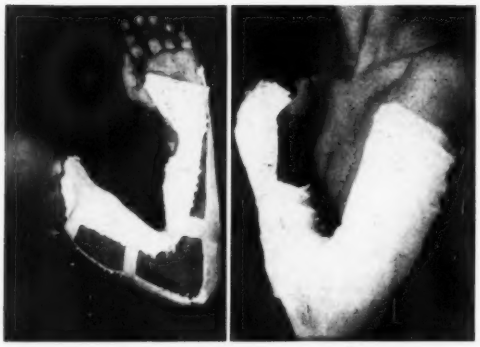
Fig. 5. V. S., 5 years old. On May 7, 1927, patient fell on his left elbow and sustained a supracondylar fracture of the humerus. Under an anesthetic and with the aid of the fluoroscope, an attempt was made to reduce the fragments and the elbow was immobilized with plaster splints in acute flexion. The radial pulse became obliterated and the fingers began to swell. The forearm was then suspended by means of adhesive at right angles to the elbow, and this was followed by a return in pulsation. a, Persistent rotation and forward displacement of the proximal fragment accounting for the pressure on the neurovascular structures and the obliteration of the radial pulse. b, c, and d, Taken June 10, 1927, January 21, 1928, and September 7, 1929 respectively. These photographs show the persistent posterior displacement of the lower fragment with the periosteum stripped off the posterior aspect of the proximal fragment, with the gradual absorption and recession of the anterior displaced proximal fragment as the distal fragment continues to grow downward. e and f, Taken January 14, 1933, shows the contour of the shaft of the humerus assuming a normal appearance. At this time the function and carrying angle was normal.

Fig. 6. G.R., aged 9 years, sustained a supracondylar fracture of the left humerus on August 1, 1934. a and b, Taken August 4, 1934, show marked posterior and mesial displacement of the distal fragment. c, August 8, 1934, persistent displacement after second attempt at reduction still evident. d, August 15, 1934, a satisfactory reduction of the posterior displacement is shown after the third attempt. e, September 6, 1934, the mesial displacement of the distal fragment has not been completely replaced. f, September 14, 1934, satisfactory reduction of the posterior displacement with some periosteal stripping.

Fig. 6 j

g, persistence of mesial displacement of distal fragment with extensive reparative process under stripped periosteum. h and i, October 10, 1936, continued downward growth of lateral aspect of the lower end of the humerus resulting in a varus deformity as contrasted with the normal elbow. j, Photograph, November 20, 1937, showing the varus deformity. The function of the elbow is unimpaired.

Reducing the posterior displacement of the distal fragment. (1) Correction of the lateral or mesial displacement is equally as important as the correction of the posterior. Gentle pressure with the thumb and index finger on both sides of the fragments alines the ends of the bone in the proper



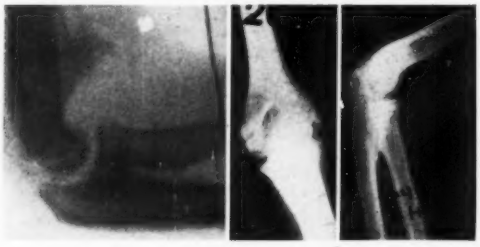
a b

Fig. 7. Immobilization in molded plaster splints. a, Flexion and semipronation with crescentic opening for palpation of radial pulse. b, Splints bandaged and forearm across the chest. Sling is omitted to show the unplastered wrist to permit access to the radial pulse.

long axis of the humerus (Fig. 2a). Failure to recognize and reduce the lateral or mesial displacement will result in a varus or valgus deformity for which even the extraordinary reparative process, due to the growth of bone, will often fail to compensate. Too much emphasis, therefore, cannot be placed on the importance of correcting the lateral slide, even though the posterior displacement has been reduced.

If the fragments are *partially impacted* and there is a *lateral displacement*, the *impaction should be broken up* by means of *rocking* the fragments. Rocking has been used by the writer for many years for breaking up impactions.

(2) The posterior displacement of the lower fragment is corrected by means of hyperextending the elbow and exerting a downward pressure on the lower fragment as advocated by Lusk, then the elbow is flexed as recommended by Jones, and the forearm is pronated as suggested by Boehler.



a b

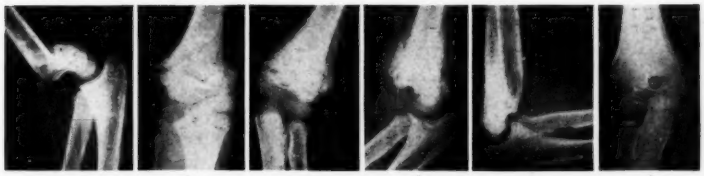
Fig. 9. G. H. a, Myositis ossificans resulting from kneading massage. b, Three years after discontinuing massage.

a b c

Fig. 8. Non-constricting adhesive fixation dressing with the forearm flexed and in semipronation. a, A wide strip of adhesive is placed on the ulnar side of the volar surface of the forearm close to the wrist, extending behind the mesial aspect of the semipronated forearm, along the outer side and back of the arm, close to the axilla, and over several layers of gauze which extends above and below the adhesive. b, The adhesive is continued over the inner side of the arm and forearm. (Note that the radial half of the forearm and part of the arm are not covered with adhesive; that is there is no encircling dressing and access to the radial pulse is easy. c, A thinly padded bass wood splint is applied to the back of the forearm, beginning from the metacarpal phalangeal junction to the elbow to prevent a pseudo wrist drop. The forearm rests across the chest and is suspended from the neck by a sling which is loosely tied about the wrist so as to avoid constriction.

These principles for reduction and fixation and the rocking of the elbow to correct the lateral displacement of the fragments are carried out in the following manner. Rocking is accomplished by grasping the pronated wrist and raising the forearm; the elbow is then rocked in all directions. This procedure invariably unlocks any impaction and with the aid of a little pressure the fragments become alined in their long axis. To obtain reduction of a fracture of the left arm, the surgeon stands to the left of the patient and with his left hand grasps the patient's pronated wrist. With the thumb of the right hand behind the lower fragment and the remaining four fingers in front

Fig. 10. Suspension for unreduced fractures with or without compression of the neurovascular structures.



a b c d e f

Fig. 11. R.Q. 7 years old. a, June 23, 1931, impaction and forward angulation of both fragments. b, Note slight lateral displacement of the distal fragment. Reduction was unsuccessful and when the elbow was immobilized in acute flexion in plaster molded splints, the radial pulse became obliterated and the fingers began to swell. The splints were removed and the forearm was suspended at right angles to the elbow. This was followed by a restoration of the radial pulsation. c, July 13, 1931, correction of the lateral displacement of the distal fragment is shown. d, July 13, 1931, lateral view. Note persistent backward displacement of the distal fragment with periosteal stripping and vicious union with evidence of a new shaft forming. e, November 23, 1932, lateral view. Note recession of protruding upper fragment and extent of reparative process in 7 months. f, November 23, 1932, anterior view. An appreciable downward growth of the mesial aspect of the lower end of the humerus with a deviation of the axis of the forearm is revealed. Junction of the elbow was entirely regained but there was a perceptible increase in the carrying angle.

of the upper fragment, hyperextension of the elbow is brought about by traction upon the patient's pronated wrist with the surgeon's left hand while the operator's right thumb exerts downward and forward pressure on the posterior aspect of the lower fragment simultaneously as pressure is exerted on the anterior aspect of the upper fragment by the four fingers of the surgeon's right hand (Fig. 2b). This maneuver results in the distal fragment gliding under the proximal. With the thumb and four fingers of the right hand maintaining pressure upon the lower and upper fragments respectively, the patient's forearm is brought into a position of *acute flexion and the forearm is semipronated* (Fig. 2c). The position of the fragments is now checked by means of the fluoroscope.

If a fluoroscope is not available, lateral and anteroposterior roentgenograms should be obtained before the retentive dressing is applied. These maneuvers should be repeated if a satisfactory reduction of the fragments has not been obtained. The use of force during manipulation is contra-indicated lest the serrations upon the ends of the fragments be destroyed or damage be inflicted to the soft parts.

What constitutes a satisfactory reduction? Obviously a normal re-alinement means a satisfactory position of the fragments; this should result in an early functional recovery without deformity (Fig. 3, Case L. K.—a, b, c, d, e).

A partial reduction of a posteriorly displaced lower fragment is satisfactory provided the rotation has been corrected and there is no mesial or lateral displacement. For example, in the case of L. C. (Fig. 4 a, b, c, d.), the displaced lower fragment became the base of the new shaft as the reparative process developed within the confines of the periosteum which had been stripped off the posterior aspect of the upper fragment and the end of the anterior displaced upper fragment became absorbed and receded as the lower fragment continued to grow downward. In this way the contour of the shaft of the humerus assumed a normal appearance, there was no deviation of carrying angle, and functional recovery was restored with no disability.

A persistent overriding or a lateral or mesial displacement must be considered as unsatisfac-

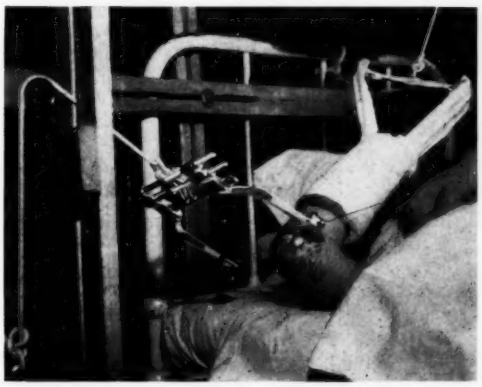
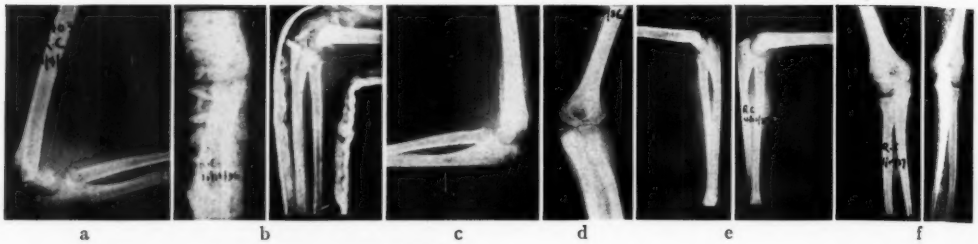


Fig. 12. Skeleton traction. The Kirschner wire is inserted through the base of the olecranon process, distal to the epiphysis. Balanced traction is made with the forearm in a position of flexion and semipronation.



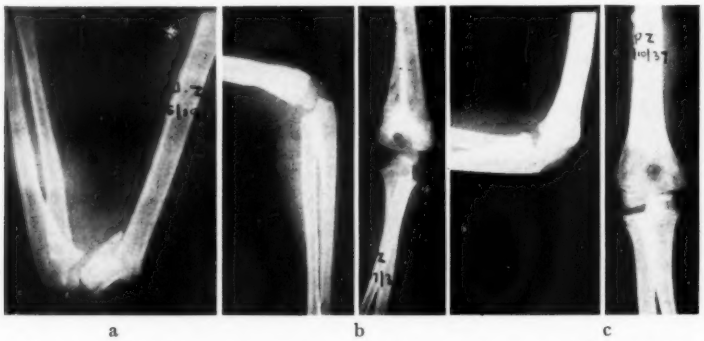
a b c d e f

g

Fig. 13. R.C. a, November 4, 1936, anterior displacement of distal fragment. b, November 11, 1936, anterior view with arm in plaster reveals a slight lateral displacement of distal fragment, lateral view shows a perfect reduction. c and d, November 30, 1936, note periosteal stripping and lateral deviation of the forearm. e and f, April 11, 1937, note the increase in the transverse diameter of the lower end of the humerus and new bone growth above the capitellum and the periosteal stripping as contrasted to the normal elbow. g, November 20, 1937, photograph showing relative position of both carrying angles.

tory as persistent overriding of the fragments may cause (a) Volkmann's ischemic paralysis, or (b) vicious union. With exuberant callus vicious union impairs function or delays functional recovery. I believe that every surgeon has at one time seen such a case where persistent overriding of the fragments has caused the formation of vicious union, which later with the absorption of the exuberant callus has resulted in a complete anatomical and functional recovery (Case 1, V. S., Fig. 5 a, b, c, d, e, f). Not all such cases will necessarily result in complete restoration of function. Some may have residual deformity or a limitation in function. To permit the fragments to remain overriding with the thought that the ultimate results may be satisfactory is beset with danger and is not to be recommended.

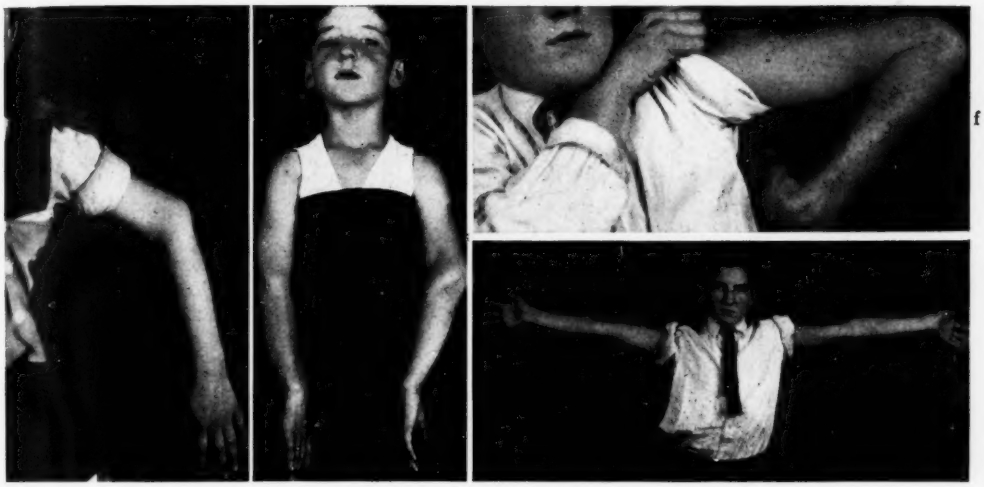
A correction of the posterior displacement of the lower fragment without a complete reduction of the lateral or mesial displacement may result in a varus or valgus deformity which can be corrected only by means of a cuneiform osteotomy.



a b c

Fig. 14. J. Z. a, August 19, 1931, after two attempts to replace fragment some posterior angulation persists. b, October 17, 1931, inward displacement of the lower fragment not completely reduced; periosteal stripping and a new shaft in process of formation with downward growth of outer aspect of lower end of the humerus. c, April 10, 1937, 5½ years later. Some varus deformity present but function is complete.

a b c



d e f g

Fig. 15. F. B., 5 years old. a, September 22, 1924, anterior displacement of distal fragment. b, October 11, 1924. Persistent forward and upward displacement of the forearm and distal fragment. c, December 25, 1932, 8 years later. Note contour of lower end of humerus in its relation to the articular surfaces and the resulting carrying angle. d, e, f, g, Photographs made on September 22, 1924, September 19, 1925, and November 12, 1932, when patient was 5, 6, and 13 years old, respectively. There is an almost imperceptible varus deformity.

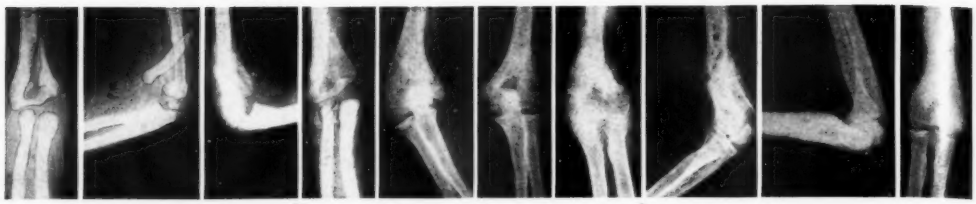
FIXATION OF FRAGMENTS

Reduction and fixation of the fragments in this series were obtained by the following methods:

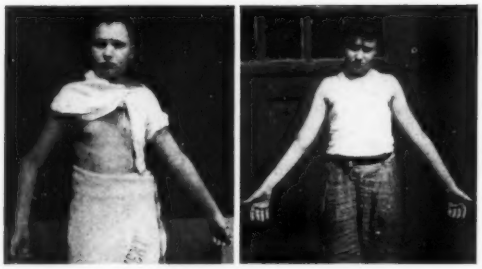
	Cases
1. Reduction and immobilization in molded splints of plaster of Paris	106
2. Reduction, adhesive plaster dressing, followed by early mobilization	178
3. Suspension for unsuccessfully reduced fractures with or without compression of the neurovascular structures	40
4. Immobilization in a Thomas splint in the treatment of compound fractures	4
5. Skeleton traction by means of a Kirschner wire through the olecranon for "T" or "Y" shaped fractures and in the treatment of compound fractures	1
6. Open operation	1
	330

In one case, G. R. (Fig. 6 a, b, c, d, e, f, g, h, i, j) a varus deformity resulted because the mesial displacement of the lower fragment was not corrected.

1. *Immobilization in molded splints of plaster of Paris.* With reduction completed, the elbow is immobilized in a position of acute flexion with the forearm semi-pronated by means of anterior and posterior molded splints which extend from the shoulder to the base of the first metacarpal. A large crescentic opening should be cut in the plaster so that the radial pulse can be palpated (Fig. 7). The elbow must not be flexed beyond a point where resistance is encountered lest the brachial artery be compressed. Diminution or obliteration of the pulse with the elbow flexed



a b c d e



f g

Fig. 16. P.M., 6 years old. a, June 11, 1931, comminuted fracture extending into mesial epiphysis, inner fragment rotated anteriorly and displaced forward. (Unsuccessful efforts were made to re-align the fragments.) b, July 6, 1931, 22 days after excision of the loose fragment. Note extensive callus proliferation on lateral and the defect on anterior view. c, October 1, 1936, pronounced gun stock deformity caused by the defect on mesial aspect of humerus resulting in a downward growth of the lateral side of the distal end of the humerus as compared to the normal elbow. d, September 2, 1937, 1 month after the removal of the Lane plate. Note the enormous deposition of callus. e, January 3, 1938, 5 months after the removal of the Lane plates. Note the disappearance of the excess callus and the contour of the shaft; also the slight increase of the carrying angle to allow for future downward growth of the lateral aspect of the distal end of the humerus. f, Photograph June 23, 1937, the extent of the gun stock deformity. g, Photograph November 25, 1937, 5 months after the cuneiform osteotomy. Slight over correction was done to allow for any future downward growth of the lateral aspect of the lower end of the humerus.

beyond a right angle indicates compression of the neurovascular structures in the antecubital fossa by the distal end of the upper fragment. Failure of the patient actively to flex and extend the fingers is frequently the first intimation of neurovascular impairment. These signs are warnings of the most serious complication in the treatment of fractures about the elbow, namely a Volkmann's ischemic paralysis. The recognition that the radial pulse is impaired is an indication that a further attempt at reduction should be made, or that the limb be suspended, as by either of these methods the pressure upon the neurovascular structures may be relieved.

A roentgenographic examination should be made after the elbow has been immobilized in plaster. It is quite often difficult to visualize the outline of the fragments in the anteroposterior plane with the elbow in flexion when the roentgenograms are taken through four thicknesses of plaster splints (Fig. 3 c). Nevertheless repeated roentgenograms should be made until the fragments can be visualized to ascertain the presence of mesial or lateral displacement.

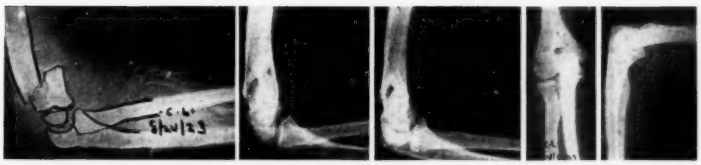
After the splints have been applied, the wrist is suspended with a sling from the patient's neck. At the end of 2 weeks the splints are removed and the forearm can be placed in a sling with the elbow at a right angle. To hasten function the patient is instructed to grasp his wrist with his other hand and with this support actively flex and extend the elbow, several times each hour. After another 2 weeks the sling is discarded.

Passive motion is believed to be harmful and should never be practised; active movements not only exercise the muscles but allow the patient to gauge the amount of movement that is permissible for the movements are gauged by pain.

a b

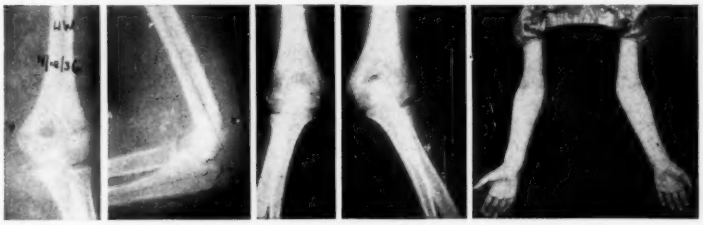
Fig. 17. E. G., 7 years old. a, August 14, 1936, 19 days after admission, after persistent attempts at reduction. Anterior and some mesial displacement of the lower fragment still persist. b, May 29, 1937. Note the extraordinary reparative process resulting in a satisfactory restoration of the contour of the humerus with an excellent functional recovery.

2. *Adhesive dressing followed by early mobilization.* In 1924 I expressed a preference for the fixation of the injured elbow by means of a nonconstricting adhesive plaster dressing in the posi-



a b c d e

Fig. 18. C.L., 7 years old. Compound supracondylar fracture, fracture of skull and compound fracture of the femur. a, August 24, 1923, anterior and rotary displacement of the lower fragment, osteomyelitis developed treated in suspension. b and c, April 15, 1924, and November 1, 1926, note reparative process and changing contour of shaft of the humerus. d and e, April 3, 1937, 14 years later, restoration in contour of the shaft of the humerus and complete functional recovery.



a b c d e

Fig. 19. H.W., 9 years old. a, April 28, 1936, transcondylar fracture extending above internal epicondyle across the external condyle. b, Line through middle of long axis of shaft of humerus passes well behind the posterior border of capitellum instead of about one-third of the capitellum being behind the plane. c and d, September 16, 1937, premature ossification of the cartilage plate of the capitellum and external condyle with continued function of trochlea causing an outward deviation of the forearm as contrasted to the normal elbow. e, Photograph September 16, 1937, indicating the extent of outward deviation of the axis of the forearm.

tion of flexion with the forearm supinated. This method has subsequently been modified by placing the forearm in a position of semipronation (Fig. 8 a, b, c) as it was observed that in the earlier cases the forearm invariably assumed a pronated position irrespective of the efforts made to retain it in a position of supination, and as this pronated position relaxes the flexor-pronator group of muscles the danger is lessened of a recurrence of the displacement which may result in a change of the carrying angle.

The advantage of the adhesive plaster dressing over plaster splints is that the patient can actively exercise the elbow during the entire period of immobilization, and in this manner stimulate the absorption of the extravasated blood and prevent muscular atrophy. The return of function is thus hastened. These active motions can be taken within the confines of the dressing and as the swelling subsides the dressing can be reapplied from time to time so as to increase the range of motion. As in the case of immobilization by splints, forced motion is contra-indicated. At the end of the third week after the dressing has been finally removed, the range of motion can be further increased. Complete function should be regained in from 6 to 12 weeks following the accident.

It has been observed that in the cases in which the elbow has been completely immobilized for too long a time, as in a plaster splint, the return of function is delayed for a longer period than in the cases in which incomplete mobilization for a similar period by means of adhesive plaster dressing has been used.

Physiotherapy was formerly used but we have discontinued it as it was observed that in those cases in which massage and other means of physiotherapy were used the structures about the elbow became more rigid, thereby increasing the time before function was restored. In some of these cases bony changes occurred in the muscles, a myositis ossificans traumatica (Fig. 9). We have recently therefore used only active motion by means of occupational therapy which has given better results.

The objection to adhesive plaster dressing and the reason for reverting to the use of plaster splints lie in the fact that the dressings so fre-

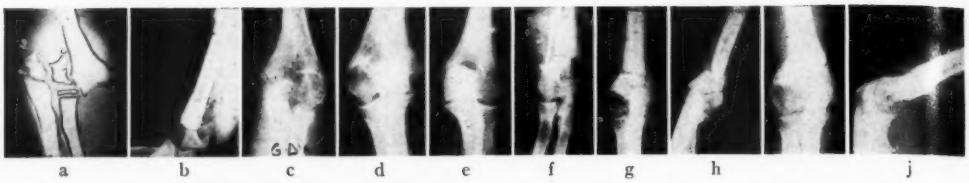


Fig. 20. G.D'A., 10 years old. a, November 3, 1924, comminuted supracondylar fracture with mesial displacement of the distal fragment. b, November 25, 1924, posterior displacement partially corrected. Note periosteal stripping. c, November 25, 1924, note downward growth of outer aspect of lower end of humerus. d and e, October 13, 1936, continued downward growth of outer aspect of lower end of the humerus with inward deviation of the axis of the forearm. Note olecranon fossa as contrasted to the normal elbow. f, July 24, 1937, 1 month after cuneiform osteotomy and insertion of a Lane plate to maintain the fragments in their corrected position. Patient now 22 years old. g and h, September 13, 1937, 3 days after removal of Lane plate. Note absence of prolific callus as compared to d. i and j, January 8, 1938, 7 months after cuneiform osteotomy. k, October 13, 1936, marked gunstock deformity. l, November 8, 1937, 5 months after cuneiform osteotomy. Complete extension and normal axis of the forearm in relation to the elbow.

quently are applied improperly and cause constriction of the arm, which produces in turn an unnecessary amount of dependent swelling about the elbow, and necessitates frequent reapplication.

The adhesive plaster dressing properly applied has caused fewer complications and produced earlier restoration of function than plaster-of-Paris splints. Unless meticulous attention can be paid to the proper application of adhesive plaster so as to prevent possible constriction, it is better that molded plaster splints be used.

3. *Suspension for unreduced fractures with or without compression of the neurovascular structures.* In neglected cases which are seen late, it is often necessary to suspend the extremity by means of skin traction applied to the forearm, as the marked displacement and swelling may make reduction of the fracture most difficult or impossible (Fig. 10). The surest way of relieving compression of the brachial vessels is to reduce the fragments. However, in a large number of the cases the suspension method has to be followed, as it does ease the pressure upon the neurovascular structures even though it is not efficient in reducing the fragments of a supracondylar fracture in which there is displacement. As soon as the swelling has decreased, the suspension can then be discontinued and an attempt can be made to obtain a reduction of the fragments. Continuing the suspension without reducing the fragments results in mal-union and the formation of an excessive amount of callus which may cause a persistent deformity and prolonged disability. At times extremely good results are obtained as the reparative powers of children are such that even with persistent displacements, normal function and anatomical conformation will finally follow (Case 7, R. Q., Fig. 11). This return may be delayed beyond the period of time required in cases in which satisfactory reduction has been obtained. It is evident from these statements that there is no justification in failing to attempt to obtain reduction of the fracture, as reduction shortens the period of disability and obviates prolonged reparative process.

4. *The Thomas splint* was used in the treatment of four compound supracondylar fractures. It permitted ready access to the wound but otherwise it had no advantage over the overhead pulley adhesive plaster suspension of the forearm at right angles to the elbow.

5. *Skeleton traction.* The suspension of the elbow by means of the Kirschner wire through the base of the olecranon process of the ulnar has been advocated by some in cases in which the fragments can not be held in position. This type of suspension may be indicated in cases of persistent posterior displacement with impending neurovascular changes. In the treatment of compound fractures the use of the Kirschner wire should be of great advantage in permitting ready access to the wound for dressing (Fig. 12).

6. *Open operation.* Our experience in open operations for the reduction of a supracondylar fracture has been limited to one case and in that it was done for the excision of a loose articular fragment. The roentgenogram must not be the sole factor in determining upon open operation.

a b c

d

Fig. 21. O.T., aged 9 years. a, August 16, 1936, supracondylar fracture extending into mesial epiphysis with slight posterior and inward displacement of distal fragment. b, August 21, 1936, persistent displacement of distal fragment. c, December 9, 1936, lateral view shows a subperiosteal deposition of callus, while the anterior view shows the varus deformity because of failure to correct the mesial displacement and probable impairment of the mesial epiphysis. d, June 12, 1937, marked gun-stock deformity.

Cognizance should be taken of the reparative powers of the child under proper supervision, especially in view of the satisfactory end-results obtained with various types of supracondylar fractures treated by the closed method.

ANTERIOR DISPLACEMENT OF DISTAL FRAGMENT

The lower fragment was displaced forward in 14 of the 330 supracondylar fractures (4 per cent). Eight of these had no mesial or lateral displacement; in 1 the lower fragment was displaced inward and in 5 rotated outward. Two of these fractures extended into the mesial epiphyses. In 3 the lower fragment was impacted, being angulated with the upper fragment in a position varying from 30 to 90 degrees. This injury, frequently termed the flexion type of supracondylar fracture, resulted from direct violence in all the cases. The usual history elicited was that the child fell on the flexed elbow.

In 13 cases the fracture was simple and 1 was compound. The compound fracture was complicated by a fracture of the skull and a compound fracture of the femur. Six of these fractures were transverse and 8 were oblique. Three of the transverse and 2 of the oblique fractures were comminuted. The varying displacements of the lower fragment, which have been referred to previously, were accompanied by stripping of the periosteum from the anterior surface of the proximal fragment and off the posterior surface of the lower fragment. It is of interest, that there was no impairment of the neurovascular structures in any of these cases either before or after attempts at reduction. With the exception of the case of compound fracture, an effort was made in all the others to correct the displacement with the aid of the fluoroscope. In 5 cases a fair or a satisfactory reduction was obtained, in 1 (Case 7, R. C.) three attempts at reduction were made before a satisfactory alignment was obtained.

Case 7. R.C., 7 years old, female, was admitted to the hospital November 4, 1936, with a simple oblique supracondylar fracture in which the distal fragment was displaced completely forward. After the third attempt at reduction, the anterior fragment was replaced with only about 10 per cent lateral displacement. The elbow was immobilized at right angles in molded plaster splints for 3 weeks. By the aid of occupational therapy complete function was regained in approximately 4 months. Roentgenographic examination on April 10, 1937, 6 months later, revealed an increase in the transverse diameter of the lower end of the humerus with periosteal stripping and new bone proliferation from the laterally displaced lower fragment. This accounted for the increase in the carrying angle of 5 to 10 degrees (Fig. 13 a, b, c, d, e, f, g).

Two attempts were made to replace the distal fragment in Case 10, J. Z., in which some inward

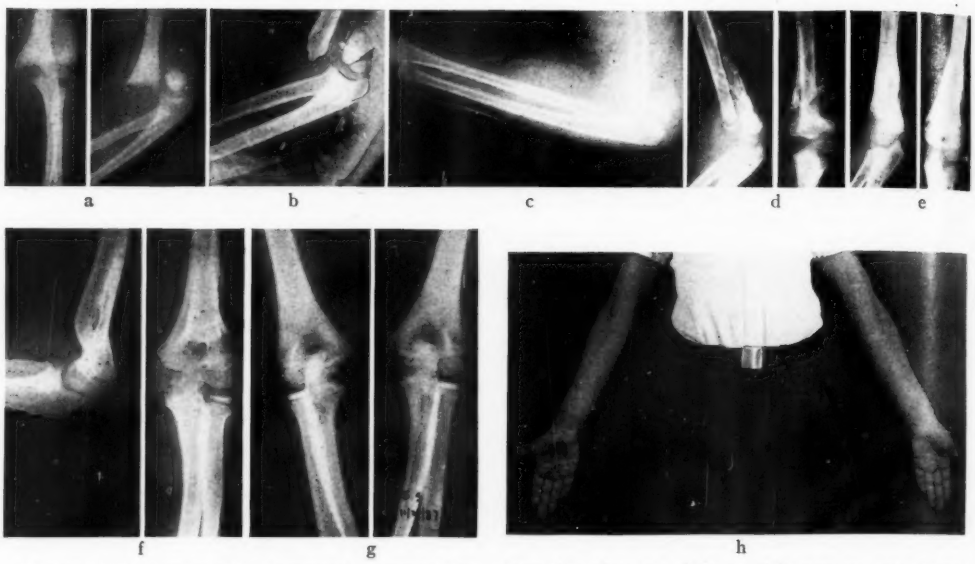


Fig. 22. S.S., 4 years old. Compound supracondylar fracture and a fracture of the lower end of the radius and ulna, on September 13, 1933. a, September 13, 1933, posterior and mesial displacement of distal fragment and anterior rotation of upper fragment. b, September 19, 1933, persistent posterior displacement of distal fragment immobilized in a posterior molded splint. c, October 3, 1933, after another attempt at correction. The posterior displacement persisted, note periosteal stripping; the forearm was suspended. d, November 11, 1933, note extent of periosteal stripping and the deposition of callus in the formation of a new shaft. e, February 27, 1934, lateral view showing extent of subperiosteal new bone formation with persistent posterior displacement of distal fragment and the anterior view showing the extensive reparative process. f, October 10, 1935, note the extent of the absorption and recession of the proximal fragment and the contour of the shaft of the humerus. g, November 20, 1937, 4 years later. The shaft has been restored to normal. h, November 20, 1937, deviation of the axis of the left forearm is practically the same as the right. This was taken more than 4 years after accident.

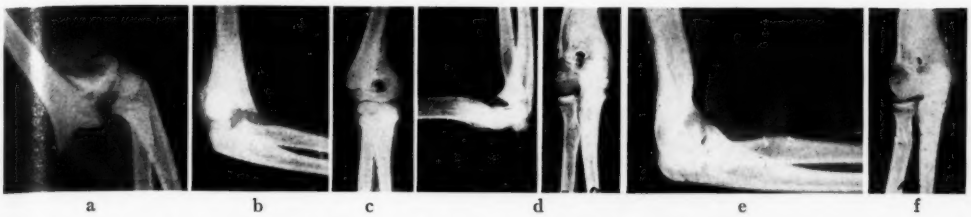
displacement of the lower fragment persisted resulting in a permanent varus. This child was followed for 6 years (Fig. 14, a, b, c).

In 5 children the forward displacement of the distal fragment could not be reduced.

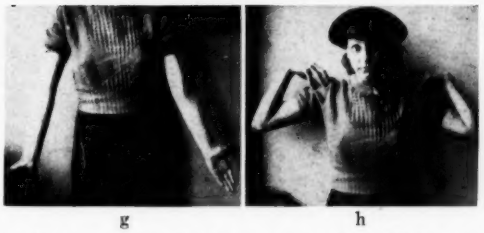
Case 11. F. B., male, aged 5 years, was admitted to Bellevue Hospital on September 22, 1924, 1 hour after falling off a bench and striking his left elbow. Marked swelling and distortion were noted about the elbow. Roentgenographic examination revealed complete anterior displacement of the lower articular end of the humerus (Fig. 15 a). Two attempts were made to improve the position of the fragments by means of extension and flexion. Roentgenographic examination on October 11, 1924, revealed the capitellum in its normal position in relation to the sigmoid with forward and upward displacement of the forearm; capitellum and the rest of the distal fragment resting at right angles to the anterior surface of the proximal fragment (Fig. 15 b). Roentgenographic examination on December 25, 1932, at the age of 13 years, revealed the trochlea and capitellum epiphyses ossified with almost normal contour of the articular surface. There is also marked bony growth of the lower and particularly the outer end of the humerus with angulation of the distal end of the humerus (Fig. 15 c.). The photographs were taken September 22, 1924, September 19, 1925, and November 12, 1932, when patient was 5, 6, and 13 years old, respectively. They reveal the gradual improvement in appearance of the elbow and the excellent range of mobility and almost imperceptible varus deformity (Fig. 15 d, e, f, g).

Case 4. P.M., male, 6 years old, was admitted to the hospital on June 6, 1931, with a comminuted fracture of the lower end of the humerus which extended into the mesial epiphysis. The inner fragment, which was fractured from the distal part, was approximately 1½ inches long and was rotated anteriorly and displaced above the articular surface. This could not be replaced and on June 14, it was removed. Because of the defect a pronounced inversion of the forearm resulted. The overgrowth of bone upon the lateral condyle and condylar ridge caused a premature ossification of the remainder of the inner humeral epiphysis. The varus deformity was corrected on June 11, 1937, by a cuneiform osteotomy, and two Lane plates were used to retain the divided bones in their corrected position. The plates were removed on August 2, 1937, because of the excessive deposition of callus. With the removal of the plates the callus became absorbed. A satisfactory restoration of the bony contour and function of the elbow has resulted (Fig. 16 a, b, c, d, e, f, g).

Case 6. E.G., male, 7 years old, was admitted to the hospital July 26, 1936, fell on his left elbow, sustaining a simple supracondylar fracture which extended into the



a b c d e f



g h

Fig. 23. R.P., 6 years old. a, September 1, 1928, complete posterior displacement of the distal fragment and forward rotation of proximal fragment. Incomplete reduction and immobilization in plaster accompanied by obliteration of radial pulse and edema of the hand. The forearm was suspended and the pulsation was restored. b, September 28, 1928, incomplete reduction and persistent rotation forward of the proximal fragment. c, November 5, 1928, incomplete reduction of the mesial displacement of the lower fragment with the formation of a new lower end of the shaft of the humerus under the stripped periosteum. d and e, November 20, 1933, and May 2, 1936, the extent of the reparative process and the recession of the projecting proximal fragment are shown. f, May 2, 1936, anterior view showing reparative process with slight downward growth of the outer aspect of the lower end of the humerus. g and h, October 14, 1936, the range of mobility of the elbow is compared with movement of left arm.

mesial epiphysis. The distal fragment was displaced completely forward and partially inward. Efforts at reduction of the anterior displaced distal fragment was unsuccessful but the mesial displacement was corrected by suspension and the elbow was later immobilized in plaster splints. Within a year a new shaft had grown from the distal fragment within the confines of the stripped periosteum from the anterior surface of the proximal fragment. The overriding proximal and posteriorly displaced fragment had become absorbed. Although the functional recovery was delayed, function was entirely regained at the end of a year without any disturbance in the carrying angle (Fig. 17 a and b).

Case 8. V.DeB., male, 8 years old, was admitted to hospital on July 19, 1936, with an oblique comminuted supracondylar fracture with 30 degrees of anterior angulation and some outward displacement of the distal fragment. The impaction did not change after an attempt at reduction. The elbow was then immobilized in acute flexion with molded splints for 3 weeks. In 3 months the function had been completely regained with a barely perceptible increase in the carrying angle.

Case 14. C.L., female, 7 years old, was admitted to hospital July 24, 1923, with a history of having fallen from a roof one-half hour before admission. She had evidence of a fractured skull, a compound fracture of the left femur and a compound oblique supracondylar fracture of the right humerus with complete anterior displacement of the distal fragment. Partial débridement of all the wounds was done. Carrel-Dakin treatment was instituted for the compound fracture of the femur, which was treated by suspension in a Thomas splint from a Balkan frame. A sterile dressing was applied to the elbow. After an unsuccessful attempt had been made to reduce the supracondylar fracture, the elbow was placed in acute flexion with an adhesive stripping dressing. As an infection developed about the elbow the forearm was suspended and the wound was treated with Dakin solution. The patient nevertheless

a b c d e f

Fig. 24. T.K. a and b, July 31, 1933, forward rotation of the proximal and lateral and posterior displacement of the distal fragment. c and d, August 3, 1933, realignment of lateral displacement but some posterior displacement persists. e and f, October 28, 1933, note new shaft on lateral roentgenogram and slight lateral displacement of the distal fragment with some periosteal stripping on the lateral border of the humerus. One year later the carrying angle showed an increase of 15 per cent.

Fig. 25. An effective form of occupational therapy.

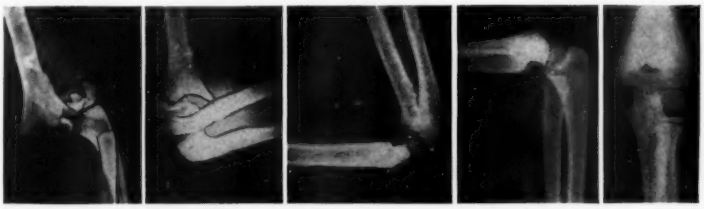
developed an osteomyelitis of the fractured humerus and femur. The wounds gradually healed and the patient was finally referred to occupational therapy. For months the elbow was very resistant to treatment but gradually function returned until it was finally complete. Some atrophy of the interosseous muscles of the hand developed but there was no impairment of sensation of the skin supplied by the ulnar nerve. With massage and high frequency current the condition of the hand improved after about 2 years. When seen in April, 1937, 14 years after injury, the patient had complete function of the elbow with no evidence of ulnar nerve impairment. The previous ulnar nerve disturbance was attributed to the pressure of a prolific amount of callus. With the absorption of the callus and the restoration of the normal contour of the humerus, the signs and symptoms of ulnar injury disappeared (Fig. 18, a, b, c, d, e).

In evaluating the method of treatment in these 14 cases of forward displacement of the distal fragment, it appears that the results were equally satisfactory whether complete reduction was obtained or not. There was no limitation of function in any of the 13 cases that were followed; in 1, Case 12, D.G., the child, against advice, left the hospital after the fracture had been reduced and could not be traced. Three of the children in whom the fractures were not reduced, and 5 in whom a satisfactory reduction was attained, ultimately had normal carrying angles. In 3 cases there was a varus deformity; in 2 of these two unsuccessful attempts had been made at reduction. In 1 case there was a slight valgus and in another there was an increase in carrying angle due to 10 per cent displacement of the lower fragment; this child had three attempts at reduction.

Analysis of these cases would lead one to infer that a proper supervision of the patient without attempts at reduction was as satisfactory as subjecting the patient to manipulation. This conclusion, however, I believe is not justified as the function is restored earlier if the fracture is properly reduced. The principle of allowing the distal fragment to remain displaced and heal by vicious union is basically unsound, and I believe that, in all cases, an attempt should be made to obtain a satisfactory reduction, and in none should the fragments be allowed to remain out of alinement unless several unsuccessful attempts at closed reduction have been made.

EPIPHYSEAL INJURY

A separation of the lower epiphyses of the humerus as a whole which would include the centers of ossification of both the capitellum and trochlea has been referred to by some writers as a distinct entity. Our experience does not substantiate such a view. Wilson (9) has never encountered a "true epiphyseal displacement of the lower end of the humerus." A study of our roentgenograms also failed to disclose such an injury. A separation through the epiphyseal line may be apparent at first in the roentgenogram but on further study it has been found that invariably the fracture line extends across the diaphysis



a b c d e

Fig. 26. A.C., 5 years old. a, August 17, 1932, posterior displacement of the distal fragment and anterior rotation of the proximal. b, September 12, 1932, 28 days later, showing persistent forward rotation of the proximal fragment. c, The posterior displacement corrected approximately 80 per cent. The forearm was suspended on the twenty-eighth day. d, November 12, 1932, note new shaft under the stripped periosteum. e, The mesial displacement of the distal fragment was corrected by suspension.

proximal to the epiphyseal cartilage plates. In other words this type of case is a fracture through the metaphysis and not an epiphyseal separation.

In 21 instances (6 per cent) of supracondylar fractures the fracture line extended down from the diaphysis through the epiphyseal cartilage plate into one of the epiphyses. In 9 cases there was no disturbance in growth of the injured epiphysis. A premature ossification of the epiphysis occurred in 12 cases producing a loss of growth of the affected epiphysis. Normal growth on the unaffected side continued producing an abnormal carrying angle. Three of the 12 cases developed a valgus deformity from injury to the lateral epiphysis and 9 a varus from disturbance of the inner articular epiphysis. This experience has been recorded by others. Cohn (2) states that a diagnosis of epiphyseal separation can be made roentgenographically only when a gross alteration of the relationship of the epiphysis to the shaft is present.

The following 3 cases illustrate two varus and one valgus deformities resulting from injuries to one of the epiphyses.

H.W., female, 9 years of age, was admitted to the hospital April 28, 1936, 2 hours after falling and injuring the left elbow. There was an enormous amount of swelling and discoloration, more than the extent of bone damage seemed to warrant. Roentgenographic examination showed a transverse supracondylar fracture extending from above the internal epicondyle irregularly across the external condyle with some forward angulation of the distal fragment, and some irregularity of the posterior part of the capitellum epiphysis. The forearm was suspended at a right angle to the arm by means of a pulley extension frame for 9 days and then it was placed in a sling. Within 6 months there was a complete restoration of function with only a perceptible increase in the carrying angle. Eighteen months later the carrying angle was further increased almost 20 per cent. Roentgenographic studies of both elbows at this time revealed a premature ossification of the cartilage plate of the capitellum and that the cartilage plate of the trochlea had continued to function. This premature fusion of the cartilage plate had resulted in a unilateral arrest of growth on the affected side with normal growth of bone on the unaffected side resulting in a distortion and outward deviation of the axis of the forearm (Fig. 19, a, b, c, d, e).

Examination of the lateral roentgenograph taken of the elbow on admission (Case H.W., Fig. 19 b), revealed that the fracture line passed through the middle of the long axis of the shaft of the humerus and then passed well behind the posterior border of the capitellum. Attention is directed to this plane by Cohn (3). It is apparent in this case that there is some forward angulation of the lower fragment as the plane is about one-half inch behind the capitellum instead of about one-third of the capitellum being behind the plane.

CASE 2. G.D'A., male, 10 years of age, was admitted to the hospital November 3, 1924, with a history of having fallen down a coal chute shortly before admission. The right elbow was tremendously swollen and distorted. Roentgenographic examination revealed a supracondylar fracture in which the comminuted lower fragment was split down the center through the articular surface of the trochlea and the fragments were displaced posteriorly and mesially. Under an anesthetic only an incomplete reduction was obtained. The extremity was immobilized in a position of flexion at the elbow by molded plaster splints. Because of impairment of the radial pulse and swelling of the fingers, the splints were removed and the elbow was placed in traction and suspension with the forearm at right angles to the arm. The radial pulse again became perceptible and the swelling gradually disappeared. Because a considerable amount of displacement persisted another attempt at reduction was made on the eighteenth day. At this time the posterior displacement of the distal fragment was corrected to the extent of 60 per cent, and the lateral displacement was almost completely eliminated. Roentgenographic examinations 3 weeks and 4 months later revealed the full extent of the injury to the trochlea with a slight downward and outward rotation of the capitellum fragments. After 2 years of occupational therapy the function of the elbow was regained but a gunstock deformity remained. During 13 years this varus deformity has gradually increased because of the downward growth of the capitellum epiphysis. On June 23, 1937, when patient was 23 years of age a cuneiform osteotomy was performed. A Lane plate was used to maintain the divided fragments in their corrected position. On September 10, 1937, this plate was removed. A normal carrying angle was thus obtained (Fig. 20, a, b, c, d, e, f, g, h, i, j, k, l).

O.T., male, 9 years of age, was admitted to the hospital August 16, 1936, shortly after falling on his outstretched hand. Roentgenographic examination revealed a transverse fracture into the mesial epiphysis with posterior and inward displacement of the lower fragment. The mesial displacement was not corrected. Examination 13 months later revealed a complete restoration of function with a decided gunstock deformity. Roentgenographs taken at intervals revealed a subperiosteal deposition of new bone on the mesial aspect of the proximal fragment. The varus deformity remained. When the patient has attained full growth, a cuneiform osteotomy will be recommended (Fig. 21, a, b, c, d).

The study of the 12 epiphyseal injuries, resulting in deviation of the carrying angle and the 9 in which there was no complicating deformity, demonstrates the difficulty of prognosticating the end-results in this class of case.

It is *probable that the line of fracture of many more of the supracondylar fractures in this series extended into one of the epiphyseal cartilage plates than is indicated in this report.* However, there is no clinical or roentgenographic evidence in the followed cases to substantiate such a diagnosis.

This deformity can result when there is no primary displacement. Unfortunately there is nothing as far as is known that can be done to prevent it. When the deformity is pronounced a cuneiform osteotomy may be performed after the cessation of growth. It should not be corrected sooner, lest the deformity recur as a result of

the uninterrupted growth of the normal epiphyseal cartilage plate of the uninjured epiphysis.

Another reason for delaying the osteotomy until ossification is completed is that an enormous proliferation of callus is deposited after any operative procedure in the young, as shown in the roentgenogram of a child (Fig. 16 d, Case P.M., 12 years old), as contrasted with the absence of excessive callus in the case of a man of 22 years of age (Fig. 20, Case 2. G.D'A.). In the latter case all the epiphyses had united to the shaft before the osteotomy was performed. The advantage of using a Lane plate to maintain the divided bone in alinement, as suggested by Wilson (10), was forcibly drawn to the writer's attention by the 2 cases just cited. In neither of them could the fragments be held in a corrected position without the insertion of a Lane plate. In fact in the case of the child (P. M., Case 4), the roentgenogram obtained after the insertion of the plate revealed that the fragments had slipped. In consequence a second plate was applied on the following day and this maintained the fragments. It is of interest to note that with the removal of these plates the excessive callus disappeared within a few months (Fig. 16, d and e).

COMPOUND FRACTURES

Of the 330 supracondylar fractures 12 (4 per cent) were compound. All these patients were followed; 1 for 14 years, 2 for 8, 4 for more than 4 years, 4 for longer than 2 years, and 1 for 1 year. The youngest child was 3 years old, 4 were under 6 and 8 were between the ages of 6 and 10.

With the exception of one who had an avulsion of skin on the posterior surface of the elbow, the other 11 fractures were compound on the volar surface. The size of the wounds varied in proportion to the extent of the protrusion through the skin of the anteriorly displaced proximal fragment. In 6 patients the projecting upper fragment rested upon the volar surface of the forearm, the end partially or completely divested of muscular attachments.

The line of fracture in these cases was transverse in 5 and oblique in 7. With the exception of 1 (Case 12, C.L., Fig. 18, a, b, c, d, e), in which the distal fragment was displaced anteriorly, and another (Case 2, J.R.) in which there was no displacement, the lower fragment in the 10 other cases were displaced posteriorly.

A partial débridement of the wound was done in 9 of these, the wounds of 4 were closed by primary suture, 3 of them healed by primary union, the fourth became infected, developed an osteomyelitis, was treated by Carrel-Dakin technique with the arm suspended in a Thomas splint, and finally this resulted in an ankylosis of the elbow. Of the 5 remaining, the wounds of which were treated by débridement, one was packed with acriflavine gauze and sutured on the fifth day, 3 were treated from the beginning by Carrel-Dakin technique, the forearm being suspended and all healed through granulations; the fifth case, in which the wound was subjected to débridement, the arm and forearm were immobilized in plaster following the reduction. The wound became infected, the forearm was suspended, osteomyelitis developed, and though the wound finally healed with only a slight change in the carrying angle, the result was classified as only fair, as there was a limitation of flexion and pronation, each of 40 degrees (Case 10, S. S., Fig. 22, a, b, c, d, e, f, g, h).

In 3 cases the wounds were merely cleansed and the fractures reduced. One was immobilized in plaster. Another was placed in acute flexion and held by means of adhesive plaster. In both of these the wounds healed by granulation. Attempts at reduction in the third case were unsuccessful; the wound became infected, was drained, and the forearm was then suspended, but osteomyelitis developed. Eventually the wound healed, and there was an excellent return of function with no bony deformity.

Of these 12 cases of compound fracture, in 7 the fragments were immobilized following reduction by means of molded plaster splints. The wounds, in 2 of these cases, became infected, necessitating the removal of the plaster and the suspension of the forearm by means of adhesive plaster; no complications developed. In the 5 others, the elbows were maintained in plaster splints until bony union occurred. Of the remaining, 3 fractures were treated by means of traction in Thomas splints from the very beginning. In one the limb was suspended with the elbow at right angles from an overhead pulley frame. In the last case the elbow was immobilized in acute flexion by means of adhesive plaster.

The final result in the treatment of these 12 compound fractures was complete restoration of function in 10, ankylosis of the elbow in 1, and in 1 case considerable function was regained but the result had to be classified as only fair. The resulting carrying angle in the 12 cases was as follows: with the exception of the case which developed an ankylosed elbow, it was normal in 6, slightly increased in 2, and showed a loss of between 5 and 10 degrees in 3.

The major problem in the treatment of compound fractures is (1) *the cleansing of the freshly contami-*

nated wound, (2) *the reduction of the fracture especially if there is a protruding proximal fragment with or without stripped muscles*, (3) *the proper immobilization of the part, and* (4) *the method of combating the infection.* If possible, the condition of the wound being satisfactory, a compound fracture about the elbow should be treated like a simple fracture. This is often possible when there is but a small wound and there is no protrusion of bone. In this type of case the skin can be cleaned, the edges of the wound carefully freed of contaminated tissue, and a dressing applied. The fracture is then reduced and immobilized by means of a posterior molded plaster splint.

A more serious problem arises where the proximal fragment is protruding. The emergency treatment of such cases is of importance as the limb should be splinted in the position in which it is found so that the end of the bone will not be withdrawn and carry contamination into the soft parts. *Under no circumstance should traction be made during the transportation and treatment of a patient with a compound fracture with a protruding fragment.* After the patient is under an anesthetic the first aid splints can be removed. The skin about the wound should be cleansed and the wound washed with saline solution. Scrubbing of the muscles is inadvisable lest one introduce infection into the muscular planes. Especial care must be taken in cleansing the skin edges and the devitalized muscles on the protruding bone. The fracture is reduced and the elbow immobilized. If the wound is not extensive and is comparatively clean, the part may be immobilized by means of a posterior molded plaster splint in the position of acute flexion. If the wound is extensive and there is gross contamination, it seems preferable to suspend the forearm in a position of acute flexion from an overhead pulley extension frame and treat the wound immediately by the Carrel Dakin method. The same method of suspension and irrigation with Dakin's solution should be used if infection supervenes in patients treated by immediate splinting. In all of these, free drainage must be established. The primary consideration is to preserve the limb and prevent a general sepsis. Although some effort should be made to maintain the fragments in the corrected position, this consideration should be secondary. If no infection supervenes the suspension may be discontinued in a week's time when the elbow can be immobilized by means of molded splints.

CAUSES AND TREATMENT OF DELAYED FUNCTION

A significant relationship exists between the unreduced or partially reduced supracondylar fracture and delay in restoration of function. This protraction of the period of disability may be due to some complication of the fracture or may be the result of treatment.

1. Malunion. a. Persistent overriding of the fragments. In such cases there is delay in functional recovery until callus has been deposited beneath the stripped periosteum and the protruding distal part of the upper fragment has been absorbed. Because of this, attempts at closed reduction should be continued to better the position of the fragments up to as late as 2 weeks. If these attempts are unsuccessful, the soft callus can be gently dismembered so that traction can be used. Skeletal traction, by means of a Kirschner wire to be inserted 1 inch below the olecranon process, is recommended. The elbow can then be suspended by means of this traction in a position of flexion with forearm pronated. Open operation at this late date may cause the deposit of a prolific amount of callus which may result in an elbow with limited function.

Excellent functional elbows have followed in cases in which overriding remained. In these cases, massage or forcible efforts are absolutely contra-indicated, but the patient can be encouraged to use the elbow freely. The limitation in motion is overcome gradually as the excessive callus is absorbed together with the recession of the distal end of the proximal fragment.

b. Mesial displacement of the rotated lower fragment, in such cases malunion and overgrowth of the lateral condyles result. This causes a deviation of the mesial aspect of the elbow with varus deformity. Every attempt should be made to correct the rotation and mesial slide of the distal fragment before union is completed and the elbow should always be immobilized in a position of flexion with the forearm semipronated. If a pronounced varus deformity has been established, it can, when the child has reached full growth, be corrected by means of a cuneiform osteotomy (Case 3, R. P., Fig. 23, a, b, c, d, e, f, g, h).

c. Lateral displacement of the rotated lower fragment. This causes an overgrowth of the mesial aspect of the elbow and an outward deviation of the forearm. This deformity is less obvious than the varus and not as apt to affect function. It should be prevented, however, by means of proper reduction and immobilization Fig. 24.

d. Varus or valgus deformity. This is caused by a fracture of the diaphysis which extends through one of the epiphyseal plates and causes premature ossification and a unilaterally arrested growth of the affected side with normal growth of the opposite side. (For details see epiphyseal injuries.)

2. *Muscle spasm* delays functional recovery. Although this complication occurs most frequently in fractures that have not been completely reduced it may also occur after satisfactory reduction if forceful efforts or kneading massage is used (in attempts to increase the range of mobility of the elbow.) In this respect too strenuous condemnation of manipulative procedures cannot be urged, whether with or without an anesthesia. Through these procedures the injured muscles are further traumatized and though the range of mobility may be increased at first, this manipulative procedure is always followed by a greater limitation of motion and more apprehension on the part of the child. I believe that muscle spasm should never be treated by any form of physiotherapy, but that the patient should be encouraged in the use of the elbow by treating him with some form of occupational therapy (Fig. 25).

3. *Myositis ossificans traumatica.* This complication has not been encountered on the Children's Surgical Service since the first group of cases were reported. It is believed that myositis ossificans traumatica results from repeated trauma to already injured muscles and periosteum. We believe, therefore, that the presence of the 7 cases of this complication, in the former group, was the result of massage and passive motion, which we then used, for when the presence of myositis ossificans was recognized and the physiotherapy had been discontinued, all evidence of this complication disappeared within a few months. Dean Lewis believes that "periosteal stripping plays an important rôle in the development of periosteal callus and ossifying myositis." But in this series we have not observed this complication unless there was added trauma, which had been caused by some form of physiotherapy.

4. *Volkmann's ischemic paralysis.* The posteriorly displaced lower fragment carrying the forearm with it causes the neurovascular structures, which are intimately bound to the latter, to impinge upon the distal sharp end of the anteriorly displaced proximal fragment. Nine cases of impending Volkmann's paralysis were recognized in this series because of absence or impairment of the radial pulse. By recognizing this premonitory sign, further damage was averted, either by means of obtaining a satisfactory reduction of the fracture and immobilization of the part or through suspension of the forearm. Both of these methods relieve the pressure on the neurovascular structures by the proximal fragment.

Ischemic paralysis has been reported by some to be due to pressure of a hematoma within the antecubital fossa even though there be no displacement of the fragments. Others have ascribed it to constrictive dressings. Neither of these causes have been encountered in this series.

Numbness, cyanosis, swelling, inability to extend the fingers without causing pain, and impairment of sensation indicates that the disease has progressed. These symptoms are actual signs of ischemic paralysis and therefore should not be awaited before measures of relief are instituted. The slightest impairment of the pulsation of the radial artery is the warning that danger is impending.

The cases in which this complication was threatened followed unsuccessful attempts at reduction in which the arm was immobilized in acute flexion. In 8 instances, the radial pulse became imperceptible and the fingers began to swell; thereupon the dressings were removed. In 6 of these the forearms were suspended and in 2 the displacement was corrected by further manipulation after which the elbow was immobilized in flexion by means of plaster splints. In all of these 8 cases the pulsation of the radial artery immediately returned. In each the roentgenogram showed a forward displacement of the proximal fragment. The suspension of the limb in 6 cases did not improve the position of the fragments but did immediately relieve the pressure upon the neurovascular structures. With the exception of 1 case (Case 6), 5 were treated by suspension until union was firm. In this case a reduction to the extent of 80 per cent was obtained through manipulation as late as the eighth day and the elbow was then immobilized in flexion by means of plaster splints. In all 8 cases complete function was regained and none showed further signs of ischemia. One child now has a normal carrying angle, 1 a valgus and 6 varus deformities varying from 5 to 10 degrees. The change in the carrying angle resulted from a failure to correct the mesial or lateral displacement of the distal fragment.

Case 5 (A. C.) is of sufficient interest to report in detail as the circulatory disturbance was of an insidious nature, inasmuch as the condition was not recognized until 2 months following discharge from the hospital.

CASE 5. A.C., 6 years old, fell on his outstretched hand on August 16, 1932. There was the typical clinical picture and roentgenographic findings of a supracondylar fracture with a complete posterior and lateral displacement of the distal fragment. An attempt was made to reduce the fracture, following which the elbow was immobilized in acute flexion. At this time there was no evidence of impairment of circulation. The x-ray film, however, revealed an unsatisfactory position of the fragments. Another attempt

at reduction was made 2 days later, which improved the position of the fragments. There was no evidence of circulatory disturbance when the boy was discharged to the Out Patient Department at the end of 15 days. On the twenty-eighth day he was readmitted to the hospital with a limitation of extension and flexion of his fingers. The roentgenogram disclosed that the upper fragment was displaced forward and inward. The limb was therefore suspended by the forearm with the elbow flexed at a right angle. Two weeks later there was slight improvement in the mobility of the hand. However, there was definite evidence of a Volkmann's paralysis. The patient was subsequently treated by means of traction of the fingers in a banjo splint, and later with plaster splints, his wrist in flexion and his fingers in extension; this was followed by gradual extension of the wrist. Function of the elbow was slow in returning, but finally at the end of 4 years full function was obtained. However, full extension at the wrist joint remained impaired (Figure 26, a. b. c. d. e).

This case is cited to call attention to an unusually late form of ischemic paralysis. It is more than probable that the circulatory changes due to the displacement of the fragments had begun before the patient's discharge from the hospital. The onset was slow and insidious but progressive, and consequently the onset of the paralysis was overlooked until it had fully developed.

It is believed that suspension of the limb prevented the onset of an ischemia in 7 of the cases though the fragments were not completely reduced and vicious union resulted in prolonged disabilities. Proper reduction and immobilization should have precluded these sequelæ.

The treatment of Volkmann's ischemic paralysis requires particular care and patience on the part of the attendant, because it is difficult to overcome the contracture and to prevent and treat trophic ulcers.

CONCLUSIONS

An analysis has been made of 330 cases of supracondylar fracture treated on the Children's Surgical Service of Bellevue Hospital during the past 18 years.

In 72 cases (22 per cent) there was no displacement of the fragments. The distal fragment was displaced posteriorly in 244 cases (74 per cent). Fourteen cases (4 per cent) are reported with a forward displacement of the lower fragment. Of the 330 fractures, in 21 (6 per cent) the line of fracture extended into the epiphyseal cartilage plate.

Of the 292 cases which were followed, 168 (58 per cent) can be said to have excellent results, 30 (10 per cent) good, 69 (24 per cent) fair, 15 (5 per cent) poor, and 10 (3 per cent) bad. These results include 52 cases (18 per cent) which are still under treatment. Many may improve in their function and will deserve a better classification.

The cause of delay in return of function was due first to a failure to obtain a satisfactory reduction of the fracture; second, to Volkmann's ischemic paralysis; third, vicious union; fourth, muscle spasm; fifth, myositis ossificans; and sixth, pressure on the ulnar or deep muscular branch of the radial nerve until the excessive callus was absorbed.

Thirteen of the 14 cases of anterior displacement of the distal fragment obtained satisfactory end-results without operative interference.

Of the 12 compound fractures, complete function was obtained in 10 cases, partial in 1, and an ankylosis in 1. Attention is directed to the danger of using traction as a first aid method in cases in which the proximal fragment protrudes through the skin lest it recedes and contaminates the deeper part of the wound.

The sooner efforts are made to reduce the displacement the more readily can the fragments be replaced and in consequence the shorter the period of disability.

To retain the reduction of the fragments so as to prevent a cubitus deformity, the part must be immobilized with the elbow flexed and the forearm semi-pronated.

It has been found that reduction can be effected even in the presence of a soft callus as late as two weeks after injury.

Failure to reduce a posterior or anterior displacement of the distal fragment in the absence of mesial or lateral displacement may result in a normal restoration of the contour of the humerus without deviation of the axis of the forearm and a complete functional recovery.

Failure to reduce the mesial or lateral displacement or rotation of the distal fragment will result in a varus or valgus deformity which the reparative powers of the child cannot change and which can be corrected only by means of a cuneiform osteotomy.

Failure to replace the lower fragment prolongs unnecessarily the period required for the return of function, because of the time it takes for the formation of a new shaft within the stripped periosteal tube.

The anteriorly displaced upper fragment pressing upon the neurovascular structures in the tense antecubital fossa is the dominant factor in the production of Volkmann's ischemic paralysis. Suspension of the forearm averted the development of this complication in 8 cases.

The line of fracture may extend through the epiphyseal cartilage plate of one of the epiphyses and cause a premature ossification in that epiphysis, resulting in a unilateral arrest of growth,

which is followed by a deformity due to the normal growth of the unaffected epiphysis.

Open reduction does not appear to be justified in supracondylar fractures in view of the uniformly good results obtained by various procedures for closed reduction.

The author wishes to express his appreciation to Dr. Fenwick Beekman, surgeon in charge of the Children's Surgical Service, for permission to report on these cases and for his many helpful suggestions.

REFERENCES

1. Boehler, Lorenz. The Treatment of Fractures. Baltimore: William Wood & Co., 1932, 190–191.
2. Cohn, I. Observations based on a study of injuries to the elbow. Arch. Surg., September, 1921, 3: 357.
3. Idem. Observations on the normally developing elbow. Arch. Surg., 1921, 2: 455–492.
4. Jones, Robert. Injuries to joints. London: Henry Frowde, Oxford University, 1918, 87.
5. Lewis, Dean. Myositis ossificans. J. Am. M. Ass., 1923, 80: 1281.
6. Lusk, W. C. Reduction of supracondylar fracture of humerus. Ann. Surg., 1908, 37: 433.
7. Poland, J. Traumatic Separation of the Epiphysis. Landon, Smith, Elder & Co., 1898.
8. Siris, Irwin E. Elbow fractures and dislocations. Surg., Gynec. & Obst., 1925, 40: 665.
9. Wilson, P. D. Fracture of the lateral condyle of the humerus. J. Bone & Joint Surg., 1936, 18: 306.
10. Idem. Fracture of the lateral condyle of the humerus. J. Bone & Joint Surg. 1936, 18: 316.

THE USE OF METYCAINE FOR PRODUCING BLOCK ANESTHESIA OF THE SACRAL NERVES

EDWARD B. TUOHY, M.D., M.S. (Anes.), Rochester, Minnesota

THE technique and indications for producing anesthesia of the sacral nerves have been described elsewhere (1). It is not the purpose of this paper to offer any changes in fundamental procedure but to suggest that a new anesthetic agent, metycaine (6), may be used to advantage instead of procaine.

Chemically, procaine and metycaine (2) are related, in that they are both derivatives of cocaine, but the addition of substitution products causes the two agents to have different chemical and clinical properties (Figs. 1 and 2). Metycaine is both a local and a topical anesthetic agent, whereas procaine does not possess any local anesthetic action on topical application. Metycaine also possesses antiseptic properties which are not present in procaine.

Meeker and McCreary, who have compared the anesthetic potency of procaine and metycaine by means of intradermal injection, found that anesthesia which was induced with 0.0625 per cent of procaine, without epinephrine, lasted 5 minutes, whereas anesthesia which was induced with an equal amount of 0.0625 per cent of metycaine lasted 14 minutes. Several other workers (4, 5) have confirmed these observations that anesthesia which is induced with metycaine is more enduring than that which is induced with procaine. The toxicity of these agents has been studied by means of injecting them intravenously into animals. When metycaine is injected intravenously, it is found to be two or three times more toxic than procaine but, clinically, Rose and others have found that metycaine is no more toxic than procaine. Further, in comparison with cocaine, metycaine is about a fourth as toxic as cocaine and possesses considerable anesthetic power. A 2 to 4 per cent solution of metycaine is the usual strength for topical anesthesia. I have used metycaine for infiltration and block anesthesia with satisfactory results and have not noticed any evidence that metycaine was more toxic than procaine.

As an agent to produce anesthesia of an individual nerve or of several nerves such as those of the brachial or sacral plexus, metycaine has been found to produce quicker anesthesia in equivalent doses and the anesthesia lasts about 50 per cent longer than that produced with procaine. Previously 1 per cent procaine with epinephrine was the agent usually used for caudal transsacral anesthesia. With this agent and concentration, it was expected that anesthesia would be established within 12 to 15 minutes after completion of the injection and that the duration would vary from 1 to 2 hours. When 1 per cent metycaine with epinephrine is used, anesthesia usually is complete within 6 to 8 minutes after the injection has been completed and endures for 2 hours or longer. In

From the Section on Anesthesia, The Mayo Clinic.

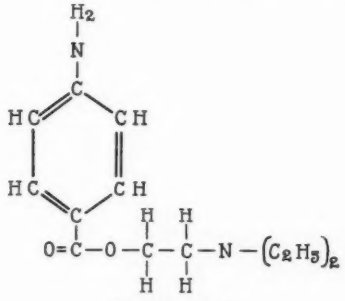


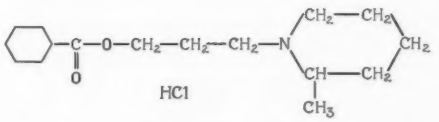
Fig. 1. Procaine.

not a few cases, when metycaine was used, anesthesia was complete when the injection was completed. The regularity with which anesthesia was rapidly established in 667 cases emphasized the advantage which metycaine has as a local anesthetic agent for sacral plexus block. There is a definite time-saving factor for the surgeon when metycaine is used because anesthesia is established quickly, and a benefit to the patient because prolonged anesthesia makes the postoperative period more comfortable.

PREPARATION OF THE SOLUTION

One 5 cubic centimeter ampul of 20 per cent solution of metycaine is added to 95 cubic centimeters of physiologic solution of sodium chloride, the temperature of which is maintained at about 37.5 degrees C. The contents of another ampul containing 1 cubic centimeter of 1:2600 solution of epinephrine is added to the solution of metycaine and sodium chloride. Under certain circumstances, such as marked hypertension or thyrotoxicosis, or in the presence of some cardiac condition such as angina pectoris, the epinephrine is omitted.

Briefly, 25 to 30 cubic centimeters of 1 per cent metycaine is injected into the caudal canal, and 15 cubic centimeters of the same solution is injected transsacrally on each side, in the second, third, and fourth foramina, 10, 3, and 2 cubic centimeters, respectively, being used. The total



Hydrochloride of gamma-(2-methyl piperidino)-propyl benzoate

Fig. 2. Metycaine.

amount of 1 per cent solution of metycaine used is usually 60 cubic centimeters.

SUMMARY

Metycaine may be substituted for procaine as a local anesthetic agent with certain advantages. It produces anesthesia in equivalent dosages more rapidly than does procaine and anesthesia is more enduring than when procaine is used. Clinically it is no more toxic than procaine as a regional anesthetic. Metycaine, which is a fourth as toxic as cocaine, may be used instead of cocaine for topical anesthesia with satisfactory results. It may be of interest to some anesthetists who are sensitive to contact with procaine that they may try metycaine as an alternative local anesthetic agent. I know of a physician who had dermatitis from procaine but who is able to use metycaine with impunity.

REFERENCES

1. Lundy, J. S. A method for producing block anesthesia of the sacral nerves. Am. J. Surg., 1928, 4: 262–270.
2. McElvain, S. M. Piperidine derivatives. IV. Substituted piperidine-alkyl benzoates and para-aminobenzoates. J. Am. Chem. Soc., 1927, 49: 2835–2840.
3. Meeker, W. R., and McCreary, P. L. Metycaine in spinal anesthesia. Am. J. Surg., 1934, 24: 139–141.
4. Romberger, F. T. Comparative scope and clinical utility of various agents and techniques in spinal anesthesia. Current Res. Anes. & Anal., 1933, 12: 152–155.
5. Rose, C. L., Coles, H. W., and Thompson, Helen E. Studies in the pharmacology of local anesthetics. III. Comparison of gamma—(2-methyl piperidino)-propyl benzoate hydrochloride with cocaine and procaine on experimental animals. J. Lab. & Clin. Med., 1930, 15: 731–735.
6. Tuohy, E. B. The use of metycaine in spinal anesthesia. Surgery, 1937, 2: 39–45.

MANAGEMENT OF THE THIRD AND FOURTH STAGES OF LABOR

Based on Eleven Thousand Deliveries

MORRIS LEFF, M.D., New York, New York

CONSIDERABLE uncertainty and disagreement as to the proper management of the third stage of labor still persists. Ever since recorded time, numerous methods have been advocated and used with variable success or failure. All agree that the third stage requires proper management but differ as to what constitutes the correct method.

The observations to be presented here are based on 11,000 cases delivered at our hospital: of these 7,500 were my own private cases delivered by me; and 3,500 cases were delivered by other doctors, and directly or indirectly supervised by me.

The third stage of labor embraces the period from the birth of the child to the delivery of the placenta. After the delivery of the placenta the puerperium is assumed to begin. However, after the delivery of the placenta there is a very important and dangerous interval that lasts from a few minutes to several hours, which requires the serious attention of the obstetrician. That interval between the delivery of the placenta and the time that the patient is safely in bed without any more danger of hemorrhage should be designated as the fourth stage. After this stage, then the puerperium can be considered to begin.

The third stage of labor consists of two phases: the first, the separation of the placenta; and the second, the delivery of the placenta. The separation of the placenta is a normal physiological process which is accomplished entirely by the contraction of the uterus and the reduction in its size as soon as the baby is born; while the second phase, the delivery of the placenta, is as a rule not accomplished by the natural forces, but must have the assistance of the obstetrician.

In primitive people, if the woman delivered in the erect posture, the cord and the placenta would be dragged out with the baby, or could come out by the force of gravity. In civilized times, with the woman delivering in the supine position, the natural forces cause the complete separation of the placenta; but as a rule these forces do not complete the process of expulsion of the placenta. The delivery of the placenta has to be aided artificially. It is only occasionally that powerful uterine contractions force the placenta out of the vagina. We must recognize as a fundamental fact, that in humans, nature does not provide for the expulsion of the placenta spontaneously, and that it is therefore necessary for the obstetrician to aid in its delivery; just as definitely as it is necessary to tie and cut the umbilical cord. Since the obstetrician must aid in the delivery of the placenta it is essential to know exactly the mechanism of the third stage. The mechanism can be ascertained in each case only by vaginal examination, as indicated in my paper, "Vaginal Examination in the Third Stage of Labor as a Guide to Its Management." (December, 1929.)

The generally considered signs of separation of the placenta are of no value. Placing a clamp on the cord at the vagina and watching its descent does not indicate that the placenta is separating, because by the time the clamp is placed on the cord the placenta is already separated. Pushing up on the uterus through the abdomen and noticing that the cord rises up with it, is no indication that the placenta has not separated; because the placenta will accompany the uterus although it is separated and is simply held by the lower uterine segment and cervix. The globular or flattened shape of the uterus is no indication that the placenta has or has not separated. There are no external signs by which we can know that the placenta has separated and is ready for delivery. Vaginal examination therefore must be done. I consider it indispensable in the management of the third stage of labor.

Vaginal examination is done by me in all stages of labor. Introducing the sterile gloved hand in the vagina does not cause infection. It gives definite and positive information as to the conditions present, and eliminates guesswork and mistakes. I am convinced that vaginal examination under aseptic precautions does not produce infection. In the 11,000 deliveries we have not had a single case of puerperal sepsis and the morbidity in general was exceedingly low.

Read at a meeting of the Section of Obstetrics and Gynecology of the New York Academy of Medicine, January 25, 1938.

When the baby leaves the uterus, the uterus contracts and is so reduced in size that the placenta cannot possibly remain attached; it is therefore cast off from the uterine wall. It is wrong to suppose that only a part of the placenta begins to separate and that it separates gradually. The entire placenta separates immediately, as soon as the baby leaves the uterine cavity.

The only exception to the immediate separation of the placenta is in the pathologically adherent placenta accreta, which fortunately occurs so rarely. In these 11,000 cases there were no cases of placenta accreta. The usual so called adherent placentas are in reality only retained placentas. The uterus in those cases is so firmly contracted down on the placenta that it gives the impression that the placenta is adherent, but in reality it is only retained. The parts of the secundis that do remain attached to the uterus are parts of the membranes around the periphery of the placenta. There is no special mechanism by which the membranes become detached from the uterus; they are dragged away from the uterus when the placenta is delivered.

The management of the third stage is as follows: When the baby is delivered the nurse follows down the uterus through the abdominal wall and holds it firmly. The baby is cared for by tying the cord, placing an identification tag on it, and treating the eyes, all of which takes about 3 minutes. If there is a probability of the rubber gloves having been contaminated during the delivery they are changed. An artery clamp is placed on the cord close to the vulva. A vaginal examination is made with two fingers of the right hand, while the left hand holds the artery clamp that is on the cord. The nurse makes pressure on the uterus forcing the placenta down and out of the uterus, aided by a little traction on the cord by the left hand. The placenta is then guided out or lifted out of the vagina by the right hand (Fig. 1). The membranes are dragged out after the placenta; to prevent tearing, artery clamps are used to grasp the membranes as they appear at the vulva. One ampul of pituitrin is injected and an ergot preparation is given either by mouth or intramuscularly.

The placenta is nearly always delivered by this procedure in about 3 minutes after the delivery of the baby. If progress is not made it may be that pressure is not exerted in the right direction. The pressure on the uterus should be so placed that the force will be exerted over the placenta and directed toward the outlet. The vaginal fingers determine whether the pressure on the uterus is in the right direction; the procedure is then continued until the delivery of the placenta is accomplished.

Fig. 1. The delivery of the placenta. Vaginal examination is made with two fingers of the right hand, to determine whether the placenta is ready for delivery. The left hand makes a little traction on the cord, while the nurse pushes down on the uterus from above and the placenta is expelled from the uterus. It is lifted out of the vagina by the right hand.

A bimanual examination is then made to assure that the uterus is well contracted and to detect lacerations. The placenta is examined by inspecting both surfaces, the membranes and the blood vessels. No elaborate methods are necessary to verify that parts are not missing.

When the fingers of the right hand enter the vagina and cervix, the placenta is encountered either in the Duncan or the Schultze position or in different variations of these presentations. The placenta is found to be separated, lying loose in the uterus, and partly protruding from the cervix into the vagina. Often the membranes at the rim of the placenta will be found attached to the uterine wall. These attached membranes frequently hold back the placenta from being expelled. The examining fingers in that case reach up in the lower uterine segment and detach the membranes from the uterine wall, permitting the placenta to come down. This does not mean that

Fig. 2. The placenta presenting in the Schultze manner. The examining finger pokes a hole in the presenting part of the placenta, permitting the accumulated blood to drain out, and the placenta to collapse and to be more easily expressed.

the placenta is not separated—only that the membranes at the rim of the placenta remain adherent. They would remain attached no matter how long one would wait, as there is no mechanism for the membranes becoming detached except by being dragged away when the placenta is delivered.

When the fingers encounter the placenta presenting in the Schultze manner, there is usually no visible bleeding, as the placenta obstructs the entire cervical outlet; but invariably there is bleeding in back of the placenta. This blood forms the so called retroplacental hematoma, which is the result of the placenta staying in the uterus, and which keeps the uterus distended and increases the bleeding. Before an attempt is made to express the placenta in that case, the accumulated blood should be permitted to drain out. This is done by poking a hole in the presenting part of the placenta with the examining finger, permitting the blood to run out and uterus to contract (Fig. 2). The placenta then folds up on itself and permits the uterus to contract further, and the placenta is then easily expelled. This procedure also avoids the splash of blood which otherwise accompanies the delivery of the placenta. To press on a uterus which is distended while the cervix is dilated, as it is when the placenta presents by the Schultze method, is to invite the danger of inversion of the uterus. By the above maneuver this is prevented. We have not had any cases of inversion of the uterus in the entire series.

Occasionally, as the baby is delivered the cervix closes down immediately. On vaginal examination the cervix will be found to be entirely closed, or only one or two fingers dilated; under these circumstances the placenta cannot be delivered although it is separated. When there is no dilatation nothing can be done but to wait for the uterus to relax and for the cervix to open up. These are the cases in which the placenta may be retained and may require anesthesia and manual removal. If a piece of placenta protrudes into the cervical canal it will act as a wedge and dilate the cervix. When the cervix is about two fingers dilated, then the examining fingers are held in the cervix and aid in the dilatation of the cervix; they are kept there until the cervix is sufficiently dilated for the placenta to be expressed. When the cervix is closed or partially closed, pressure is not made on the uterus, but it is rather allowed to relax; for with the relaxation of the uterus the cervix also relaxes and dilates. When the cervix is sufficiently dilated then pressure is made on the uterus and the placenta is expressed. It is the occasional closing down of the cervix which prevents us from delivering every placenta immediately. But when the cervix is open, all placentas are and should be delivered promptly without delay.

If the placenta is retained in the uterus, only one hour is allowed to elapse before manual removal is done. There is nothing gained by waiting any longer. The anesthesia relaxes the uterus and cervix, and the placenta can then be removed. The membranes at the margin of the placenta may be found adherent but the placenta itself is separated. It is not advisable to wait a longer time for the removal of the placenta, as persistent bleeding is bound to occur, which may be slow and small in quantity but in time adds up to a considerable amount. This blood loss is unnecessary and may become dangerous. The mental strain on the patient and the doctor in waiting must also be considered. Furthermore, we know that in about 3 hours the uterine cavity becomes invaded with micro-organisms, and if we delay the removal of the placenta it would involve manipulation in an infected area instead of in a comparatively clean uterus. By delivering the placenta promptly as has been indicated, the cervix does not get a chance to close down on the placenta, so that fewer cases of retained placenta occur which require manual removal.

The Mojon-Gabaston method of inducing the separation of the placenta has recently been resurrected. It is mentioned here only to be condemned. Fortunately, in the cases described, in

Fig. 3. Fourth stage of labor. Bimanual compression of the uterus to control hemorrhage. Two fingers of the right hand are inserted in the anterior fornix; they push the uterus up against the abdominal hand, thus causing compression of the uterus.

Fig. 4. Fourth stage of labor. Bimanual compression of the uterus with closure of the cervix. Two fingers of the right hand are inserted into the lateral fornices. They compress the cervix, closing it, and at the same time they lift the uterus up toward the abdominal hand, producing compression of the uterus.

which the method was used, the placentas undoubtedly had already been separated. Had it really been used in adherent placentas the fluid injected would have penetrated the uterine wall and caused tearing of the uterus.

When the baby is delivered and there is a gush of blood and the bleeding continues, immediate attention should be given to the placenta. The cord is promptly clamped and cut and the baby is handed to the nurse. The placenta is immediately delivered and the bleeding controlled. Any and all bleeding before the placenta is delivered is to be considered unnecessary, and is an indication that the placenta should be delivered without the least delay.

The natural process by which bleeding from the uterus is controlled is by the retraction and contraction of the uterus. Anything which helps contraction of the uterus will help control the bleeding, and anything which interferes with the contraction of the uterus will increase the bleeding. Therefore a uterus which is exhausted from a prolonged first and second stage is more apt to bleed. Anesthesia definitely interferes with the contraction of the uterus, consequently the deeper the anesthesia the longer will the uterus remain relaxed and induce bleeding. It is therefore advisable to use as little anesthesia as possible, and to discontinue it promptly as soon as the baby is delivered. For the same reason a minimum amount of anesthesia should be used during the repair of the perineum.

Pituitrin as a rule is given after the placenta is delivered; lately ergotrate is given instead, or with it. However, when the patient had been deeply anesthetized, the pituitrin is given immediately as the baby is born, even before the placenta is delivered, so as to counteract the relaxing effect of the anesthesia sooner.

The fourth stage now begins, which is concerned primarily with the control of bleeding and secondarily with the repair of lacerations. All repairs are done after the placenta is delivered.

With the hand on the abdomen the nurse continues to hold the uterus after the placenta is delivered and makes pressure on it. Two fingers of the right hand are inserted in the vagina in the anterior fornix, and pressure is made against the anterior wall of the uterus; the fingers push the uterus up against the hand on the abdomen (Fig. 3). Or the fingers pass on each side of the cervix in the lateral fornices and compress the cervix

from side to side, closing the cervix and at the same time pushing the uterus upward (Fig. 4). Thus bimanual compression of the uterus is attained. Without the fingers in the vagina the abdominal hand only pushes the uterus down in the vagina in an empty cavity but does not compress the uterus. The vaginal fingers are held against the uterus, and pressure from above is continued until the uterus is felt to be well contracted. This method of vaginal examination and bimanual compression of the uterus is done practically as a routine in all deliveries. Before the fingers are removed all clots are removed from the cervix and vagina, and the cervix and vagina are palpated to determine the extent of any and all lacerations.

When the uterus is very much relaxed and the bleeding is considerable, the entire hand is inserted in the vagina and the fingers gather up the walls of the cervix and compress it from all sides; at the same time the uterus is pushed upward against the abdominal hand until compression of the uterus is attained (DeLee Fig. 714). At frequent intervals the cervix is allowed to open up so that the accumulated blood can escape and the clots can be expressed. The uterus cannot contract properly while there are clots in it. The oxytocics are repeated if necessary. Contraction of the uterus and control of bleeding must be attained.

Bleeding below the clitoris should be promptly observed and must receive immediate attention, as it may be very profuse. Pressure controls it temporarily until the tear is sutured.

When a vaginal hematoma is detected in the process of forming it should be incised. The vessels can then retract and the bleeding will cease, or the bleeding area should be sutured. The vagina should be packed with iodoform gauze whether the hematoma is incised or not, so as to produce pressure and thereby prevent its extension. When the patient complains of severe pain in the vagina radiating toward the rectum, vaginal hematoma should be suspected.

Packing the uterus to control bleeding is not resorted to, as it is not considered desirable. Although to pack a uterus is not a difficult procedure, to pack it perfectly and completely is not simple. With whatever quantity of gauze the uterus is packed, the uterus may still further relax, as it is not a solid structure, and the bleeding may not be controlled. On removal of the packing hemorrhage may recommence. It is unphysiological to pack the uterus, as the means of controlling the hemorrhage is for the uterine muscle fibers to retract and contract and eliminate the sinuses, whereas if the uterus is packed the sinuses remain distended.

Packing the vagina is done very frequently. Its main object is to fill the empty cavity of the vagina so that pressure can be made on the uterus from above against something solid instead of an empty space. It also aids in controlling bleeding from the vagina or cervix. When the bleeding is more or less controlled by bimanual compression as has been described, and the uterus still has a tendency to relax, then the vagina is packed as a precaution against further bleeding. Packing is not done while the bleeding is still continuing. The bleeding must first be controlled by bimanual compression, otherwise clots will be retained in the cervix and the uterus and induce more bleeding. Iodoform gauze (5 per cent) is used for packing. The gauze is 8 inches wide folded to one inch, and ten yards long. It is put up in glass jars ready for use. The tubular packer (DeLee Fig. 790) simplifies the procedure greatly. The packer used is $^{11}/_{16}$ of an inch in diameter, and has two prongs. It should vary in diameter according to the width of the gauze used.

Even in placenta prævia it is not considered advisable to pack the uterus after delivery, as the packing will distend the sinuses and maintain the bleeding. Packing the vagina compresses the cervix, and with pressure from above, contraction of the uterus and cervix is more likely to be attained.

The patient is kept in the delivery room until all bleeding is controlled and the uterus is well contracted. Frequently the patient is in bed 15 minutes after the birth of the child, and at other times she remains on the delivery table for an hour or longer.

The repair of the perineum is done after the placenta is delivered and the bleeding is controlled. For the technique of the repair of the perineum, the reader is referred to the standard text books on the subject. DeLee's excellent illustrations describe all forms of repair. As little anesthesia should be used as is possible so as not to induce relaxation of the uterus. Cervical lacerations are not as a rule sutured, as most tears which appear extensive shrink to insignificance when the cervix contracts.

In repairing second degree lacerations or episiotomies, I find it unnecessary to suture the different structures in separate layers. The superficial and deep structures are sutured together with the same stitch. I find that if the deep layers are sutured separately, the catgut and the knots in the deep layer collect the lochia and interfere with the healing. Whereas, when a through suture is

used for the superficial and deep layers, primary union is more apt to occur. The suturing can thereby be done much more quickly and be completed before the patient reacts from the previous anesthetic, without the need of prolonging it; or it may be done under first stage anesthesia. This does not apply to third degree lacerations, which require delicate repair of the different structures. By resorting to proper episiotomies third degree lacerations can usually be avoided. While the repair is being done the uterus should be held firmly and not allowed to relax. If it tends to relax, the repair should be interrupted and attention given to the uterus.

When the patient is placed in bed she still needs watching, as the uterus is still liable to relax. Abdominal binders are used postpartum, as the patients prefer them; but the binder is not put on for several hours after the patient has been in bed, so that the nurse can continue to feel the uterus. In watching the uterus the nurse must know what constitutes a firmly contracted uterus, otherwise an inexperienced nurse may be holding a uterus which may be filling up with blood and be under the impression that it is well contracted.

If the uterus relaxes when the patient is in bed, all clots must be expressed. If in doubt, vaginal examination is done again and the clots are removed from the cervix and vagina. When the vagina has been packed and it is found that serum runs out through the packing, it is a sign that blood clots are accumulating in back of the packing. If the uterus rises up or fresh blood is expressed or there are other signs of bleeding or even a suspicion of bleeding, the packing is removed, the clots are expressed, and the vagina is repacked. When the patient, after being in bed, continues to complain of cramps which are more severe than the usual afterpains they may be due to blood clots in the uterus. The removal of the packing, or vaginal examination or repacking can be done in bed if necessary. Sterile towels are used to drape the area, and with sterile gloves and the tubular packer, the vagina is repacked with iodoform gauze.

It is evident from this description that we do not practise watchful waiting for bleeding in the hope that the bleeding will cease by itself. Active measures to control bleeding must be taken promptly to avoid unnecessary or excess loss of blood.

In our entire series there were no deaths directly attributable to hemorrhage. The deaths that did occur from hemorrhage were in cases of placenta prævia, and in one case of a bleeder in which the blood failed to clot and transfusion was of no avail.

It should be evident that the technique described and advocated ought to be effective in causing contraction and compression of the uterus and the control of bleeding. The great objection raised would be against doing vaginal examination, for fear of infection. The antagonism against vaginal examinations has reached the stage of a phobia or a superstition with many obstetricians. Conditions are overlooked, diagnoses are guessed at, and patients are neglected because of the unwarranted fear of making vaginal examinations. By the method described of managing the third and fourth stages, the blood loss is greatly reduced, our patients rarely require blood transfusions, and they make a better postpartum recovery. All the vaginal examinations are, naturally, done under aseptic precautions. There are absolutely no ill effects resulting from them. The morbidity is very low with no mortality from infection.

I consider vaginal examination in all stages of labor and the active treatment in the prevention and control of hemorrhage absolutely essential for proper obstetric practice.

SUMMARY

The term, third stage of labor, should be limited to the delivery of the placenta. The interval thereafter, between the delivery of the placenta and the time the patient is ready for bed, is designated as the fourth stage. It concerns itself primarily with the control of hemorrhage.

The placenta separates as soon as the baby is born. Vaginal examination is done and the placenta is promptly expressed. No ill effects result from vaginal examination.

Vaginal examination and bimanual compression of the uterus are done to control hemorrhage.

The vagina is frequently packed with iodoform gauze, but not the uterus.

The technique used for the third and fourth stages of labor, which gives very satisfactory results, is described.

REFERENCES

1. DeLee, J. B. Principles and Practice of Obstetrics, 6th ed. Philadelphia: W. B. Saunders Co., 1933.
2. Leff, M. Am. J. Obst. & Gynec., 1929, 18: 868.
3. Schumann, Edward A. Obstetrics. Philadelphia: W. B. Saunders Co., 1936.
4. Stander, H. J. Williams Obstetrics, 7th ed. New York: Appleton-Century Co., 1936.

FAT NECROSIS—GRANULOMA OF THE BREAST

S. F. LIVINGSTON, M.D., and M. LEDERER, M.D., Brooklyn, New York

THE importance of recognizing traumatic fat necrosis of the breast lies in the fact that clinically it closely resembles carcinoma.

The clinical criteria for the diagnosis or exclusion of malignancy in the breast fall short, when confronted with a tumor in a middle aged woman, who is overweight and whose breasts are fatty. Such findings as hardness of a tumor, or one that is not circumscribed, showing attachment to the skin overlying it, or retraction of the nipple, in most cases justifies the clinical suspicion of cancer. Yet the same findings are seen in traumatic fat necrosis.

This condition was first brought to the attention of surgeons by Lee and Adair in 1920 (4) when they reported 2 cases. In 1922 they reported 3 additional cases (5) and in 1924 (6) they collected all known cases from their own clinic and other sources. This formed a group of 20 cases from which they drew the following conclusions. "This condition occurs as a rule in middle aged individuals. In practically every incident the woman was far beyond the normal weight. As the disease occurs in unusually adipose individuals, the breasts are unusually large. Trauma was obtained in the history of 14, or 70 per cent, of the cases. The tumor is painless and in the majority of the cases is stony hard. The tumor may be adherent to the skin overlying or to the deep fascia. The nipple may show evidence of retraction (occurring in 20 per cent of their cases)."

Since the report of this group, a number of isolated cases have been reported. Geoffrey Keynes was the first to call the attention of British surgeons to the existence of this condition; when he reported the case of fat necrosis in a woman on whom a clinical diagnosis of cancer was made with a consequent complete amputation of the breast, pectoral muscles, and the axillary fat. Cecil Rowntree reported a case of fat necrosis in a woman in whom a provisional diagnosis of carcinoma or tuberculosis was made and an amputation of the breast was performed. Manville reported 25 cases of fat necrosis in which a pre-operative diagnosis of malignancy was made in 29 per cent of the cases. Thus, clinically, it is very often difficult to diagnose the condition excepting as in one case reported by J. J. Levin in which the presence of a tumor followed a definite history of trauma, namely, after hypodermoclysis.

The surgeon must become very familiar with the gross appearance of the tumor in order to avoid mistakes. Ewing states (6) "that the tumor is usually pale, dull, grayish white, homogeneous, and chalky in appearance. The outline of the gross lesion in carcinoma is generally much sharper than in fat necrosis, which may fade off gradually into surrounding areas. Chalky points and streaks of fatty epithelium lying in firm translucent connective tissue are characteristic of infiltrating carcinoma. The same whitish points are present in necrotic or inflamed fat tissue, but they are generally much broader and more irregular. Occasionally, one finds a whole fat lobule as large as a bean, chalky and opaque from the proliferation of fat cells, in inflamed fat tissue. Carcinomatous nodules in the breast are nearly always single, whereas traumatized fat is often very irregularly distributed and cicatrization appears in multiple points.

"The microscopic section furnishes a correct interpretation at once from the presence of much cellular overgrowth, fibroblasts mingled with lymphocytes, empty spaces once filled with fluid fat (oil cysts) and many phagocytic giant cells and wide areas of proliferating fat cells."

Keynes in his report states, "fat necrosis of the breast is not a lesion of the mammary gland proper, but the fat which overlies or infiltrates the mammary gland in later life. Grossly the appearance of 'chalky whiteness' of the necrosed areas of fat, resembles 'fat necrosis' seen in acute pancreatitis. Microscopically, the presence of embryonic fat cells and multinucleated giant cells, stamps the tissue as necrotic fat." Two illustrative case reports of this condition are offered.

The first case described is particularly instructive because, although it fulfilled all clinical criteria for a diagnosis of malignancy, it proved to be a benign lesion. The diagnosis made preoperatively was carcinoma and a radical amputation was performed. The second case was seen soon after the first, a correct pre-operative diagnosis was made, and excision of the lesion only was done.

From the Breast Clinic, Department of Surgery, and Division of Pathology, the Jewish Hospital of Brooklyn.

Fig. 1. Fat pendulous breasts. Retraction of right nipple.

Fig. 2. Intracanalicular granuloma. ×12.

CASE 1. No. 188875. A short, stout, 53 year old woman was first seen in the out-patient department of the Jewish Hospital of Brooklyn on October 11, 1934. At that time a working diagnosis was made of menopausal syndrome and obesity, for which she was treated. On February 27, 1936, she returned to the clinic complaining of a lump in the right breast of 6 months' duration. This lump had never caused any pain nor had it increased in size. Within the past month the patient had been able to express a reddish brown, and sometimes bloody, discharge from the right nipple.

Physical examination revealed a middle aged, short, and rather corpulent woman. The breasts were large, fatty, and pendulous (Fig. 1). There was a mass in the outer quadrant of the right breast about 4 centimeters from the nipple which measured 3.5 by 2.5 centimeters in size. It was firm, irregular in outline, not encapsulated and felt as though it were deep in the breast tissue. The overlying skin was adherent—and when the patient leaned forward, allowing the breast to sag, there was noticeable retraction and dimpling of the skin overlying the mass. The nipple was retracted (Fig. 1). There were two small lymph nodes about 1 centimeter in diameter palpable high in the axilla which felt soft. No history of trauma could be elicited from the patient. A pre-operative diagnosis of carcinoma of the breast was made. Because of the soft consistency of the tumor, an element of doubt was cast on the diagnosis.

The mass was excised with a good portion of surrounding normal breast tissue. Sectioning imparted a gritty sensation to the scalpel. The cut section was brown-yellow in color, granular and firm. Although it did not have the typical cicatricial appearance, nor the chalky points or streaks, nor the Bartlett pear appearance which is characteristic of carcinoma, the clinical conception of this case, more than the unusual appearance of the cut section, made one feel that a radical operation would be the safer procedure. The remainder of the breast, pectoral muscles, and axillary contents were removed. The patient made an uneventful recovery and was discharged.

Pathological report, gross. The specimen consists of a breast and associated structures. One surface is covered by an elliptical portion of skin, 21 by 20 centimeters, including the nipple. Lateral to the nipple is a gaping aperture, 8 by 4 by 3 centimeters. The underlying adipose tissue is 6 centimeters thick and attached to the posterior surface is a portion of muscle tissue, 17 by 9 centimeters. Attached to one edge of the specimen are several, firm lymph nodes measuring up to 1.5 by 1 by 1 centimeter. Their cut surfaces are pale gray and bulge. Sections through six of these were taken for microscopic study. Corresponding in shape and size to the cavity and received separately, was a portion of firm, yellow and white tissue, 7.5 by 4 by 3 centimeters. It is composed of circumscribed areas of dense, white and gray tissue. In the cut surfaces, spaces up to 0.3 centimeter are filled with firm, brown and white tissue. In one area strands of dense white tissue in a branching arrangement are noted.

Microscopic. Large lumina of ducts and acini, filled with a cellular débris, are lined by cuboidal cells with nuclei heaped up into several rows. In places the epithelium is desquamated and in the surrounding loose and dense fibrous connective tissue there are large mononuclear cells containing light staining foamy cytoplasm, with small eccentrically placed nuclei and small round cells. In some areas, parts of ducts are seen in a dense and hyalinizing fibrous connective tissue. Scattered through the connective tissue are large mononuclear cells containing rusty brown granules. Many of the ducts are distorted by the prolifera-

Fig. 3. Granuloma showing detail. ×148.

Fig. 4. Same as Figure 3. ×500.

tion of the surrounding connective tissue. No atypical proliferation of the epithelium is seen anywhere in the preparation. Occasional groups of epithelial cells, parts of lumina of ducts or acini are seen in the dense hyalinizing fibrous connective tissue stroma. Occasional groups of lumina are lined by flat cells. In the centers of some larger areas amidst the large mononuclear cells there are slit-like structures. In another area there are many giant cells of the foreign body type. In a third preparation a large lumen is seen with frequent infoldings. The surface is partly covered by epithelium and partly denuded. The connective tissue stalks appear like granulation tissue, and are loose and densely infiltrated with polymorphonuclear leucocytes and large mononuclear cells. Several such lumina are noted.

In one of the larger lumina there is a dense hyalinizing fibrous connective tissue with many giant cells of the foreign body type and large mononuclear cells with granules of rusty brown pigment. Serial sections show the central mass to be attached to the wall of the duct by a broad pedicle and entirely covered by flattened epithelium, proving it to be an invagination. It obviously is a granuloma which occupies the lumen of the duct in the same way as does an intracanalicular fibroadenoma (Fig. 2). In another section (Fig. 3) small individual complexes can be recognized consisting of a central matrix of spindle cells with small, compact oval nuclei. Lying in this mass and arranged radially are a number of oval or fusiform clefts adjacent to which are giant cells of the foreign body type (Fig. 4). Surrounding these structures are diffuse collections of small round cells. These aggregates lie in the adipose tissue. Beneath the epithelium of the ducts and in the surrounding tissue there is considerable infiltration with polymorphonuclear leucocytes and newly formed fibrous connective tissue. Preparations from the lymph nodes show looseness in texture, marked overgrowth of the germinal centers of the lymph follicles, proliferation of the sinus cells and an engorgement of the sinuses with small round cells, large mononuclear cells, some pink staining material, and many eosinophiles.

Diagnosis: Fat necrosis of breast.

Case 2. No. 189832. A 46 year old woman was admitted to the Jewish Hospital of Brooklyn on April 6, 1936, with a history of a lump in the right breast for the past 3 weeks. Occasionally she experienced a sticking sensation in the right breast.

In August, 1932, the patient complained of pain in her lower back. An x-ray examination of the lumbosacral region revealed an "osteosclerosing type of infiltration of the fourth and fifth lumbar vertebræ and upper border of the sacrum." At that time a study of the remainder of her osseous system was suggested in search for other malignant foci.

She returned to the clinic in October, 1935, when her chief complaint was pain in the right upper quadrant; a diagnosis was made of chronic cholecystitis. A cholecystographic study revealed a solitary calculus and a poorly functioning gall gladder. She was admitted to the hospital and a cholecystectomy was performed. The pathological report was "cholecystitis, chronic, with cholelithiasis."

Examination on her last admission revealed a middle aged, obese woman, with fat, heavy, pendulous breasts (Fig. 5). In the lower inner quadrant of the right breast was a mass of stony hardness, about 5 centimeters in diam-

Fig. 5. Fat pendulous breasts.

Fig. 6. Roentgenogram of mass in breast.

eter, fairly well circumscribed, freely movable, and not adherent to the overlying skin or to the deeper structures. This mass was situated deep in the breast tissue. The working diagnosis was that of cyst, with calcification. An x-ray examination of the breast revealed a well circumscribed calcified area (Fig. 6). An x-ray film of the skull failed to reveal any evidence of metastasis; there was calcification of the sella turcica. A restudy of the lumbosacral region showed no evidence of pathology in the fourth or fifth lumbar vertebræ. The calcium and phosphorous content of the blood were 11.0 milligrams per cent and 3.8 milligrams per cent, respectively. The cholesterol content of the blood was 308.0 milligrams per cent. Roentgenograms of both humeri were normal. The tumor was excised with surrounding normal breast tissue, under gas oxygen anesthesia. The patient made an uneventful recovery and was discharged cured.

Pathological Report, gross. The specimen consists of two portions of lobulated yellow tissue, 9 by 9 by 3 centimeters and 8 by 6 by 1 centimeter, respectively. In the larger (Fig. 7) there is a firm egg shaped mass, 7 by 4 by 2 centimeters. The cut surface of the mass shows it to be composed of a central core of soft, yellow tissue surrounded by a rim of firm white material which in places resembles cartilage. In the nearby adipose tissue there are circumscribed areas of yellow tissue resembling that noted in the mass.

Microscopic. In adipose tissue there are occasional groups of mammary gland acini and ducts. In nearby areas there is a dense hyalinizing fibrous connective tissue and extensive areas of adipose tissue with many large cells with foamy cytoplasm and round nuclei. In some areas there is pink staining homogeneous material and surrounding this

Fig. 7. Mass from breast.

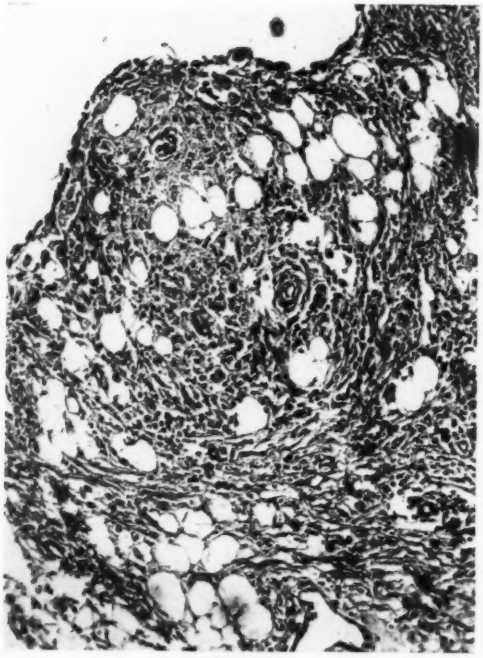


Fig. 8.

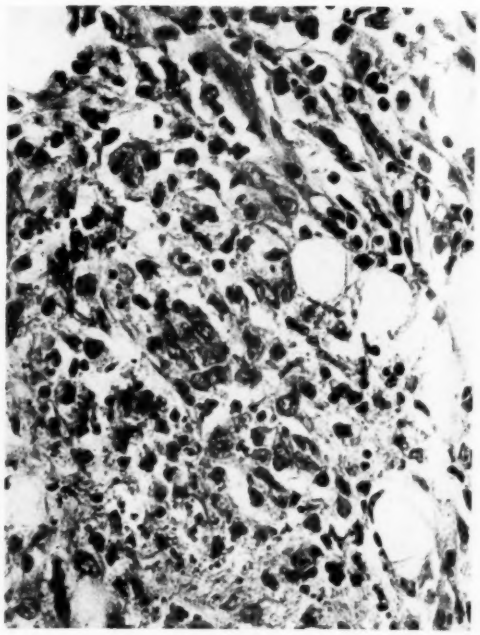


Fig. 9.

Fig. 10.

Fig. 8. Granuloma showing detail. ×175.
Fig. 9. Same as Figure 8. ×590.
Fig. 10. Calcium deposit in wall of granuloma. ×40.

and nearby, there are occasional giant cells of the foreign body type and a dense infiltration with small round cells and large mononuclear cells. In another preparation there is a broad zone of pink staining fibers with no nuclear stain. Nearby, there are collections of cells with granular staining, foamy cytoplasms and round eccentrically placed nuclei or similar cells filled with rusty brown granules (Fig. 8). Coarse collagenous bundles are seen connecting with the dense hyalinizing area. In the meshes of these bundles with no nuclear stain, there are a number of large mononuclear cells with golden yellow granules in the cytoplasms.

Diagnosis: Mammary gland with fat necrosis.

If one were to speculate regarding the cycle of evolution of fat necrosis, it can be said that first there is trauma either from external causes, or direct pressure of the breasts from their own weight. If the trauma is severe with injury to blood vessels, one may see areas of ecchymosis. If the trauma extends more deeply, there may be no visible evidence of blood extravasation. The presence of pigment in cells as seen in the section (Figs. 2, 8), suggests that there has been hemorrhage.

It is a well known fact that there is a fat splitting ferment (lipase) in the blood as well as in the

fat itself. Fat tissue being unstable breaks down very easily into its constituents, fatty acids and glycerine. Fat necrosis and fat splitting are two quite different processes, frequently allied; necrosis being the principal event and fat splitting only an accompaniment.

Two possible theories of fat necrosis are mentioned by Farr: (1) Enzyme action from liberated blood or from the fat cell itself; (2) Simple pressure necrosis from anemia with secondary fat splitting. Probably both factors take part in the process, but it is not necessary to postulate enzyme action at all for its production. In his conclusion he states that possibly no ferment action is concerned, the etiological factor being simply ischemia. Hatfield is one of those who holds firmly that fat necrosis is produced by sterile autolysis.

The necrosis of fat tissue accompanied by a splitting into fatty acids and glycerol is considered as a degenerative phase which is closely followed by repair. This repair is characterized by the appearance of spindle, round, and giant cells (Menville). In the first case described, the process of repair had gone on to the stage of fibrosis, causing a large hard tumor, which produced a retraction of the nipple. The explanation is that since the majority of fat necroses are subcutaneous, the fibrous repair tissue acts like strong cords which have no elasticity but have a tendency to retract. In the second case, the end-result of fat necrosis is cyst formation with calcareous deposits. Adair states that early in the cycle of fat necrosis, small cysts may form. After several years these cystic cavities may contain a mixture of small and large calcareous masses. If these tumors be left undisturbed, the entire cyst contents and cyst wall becomes a solid calcareous mass.

SUMMARY AND CONCLUSION

1. Two cases of traumatic fat necrosis are reported.

2. Fat necrosis must be included in the differential diagnosis of breast tumors.

3. Clinically fat necrosis more closely resembles carcinoma than other benign lesions.

4. The treatment is local excision of the tumor mass.

5. A correct diagnosis can often be made if the surgeon clearly understands and keeps in mind the gross appearance of the lesion.

Since writing this article, the diagnosis of fat necrosis granuloma was made in 2 cases before operation, and in both cases the patient was spared radical operation of the breast because of frozen section of a biopsy specimen.

BIBLIOGRAPHY

1. Farr, Charles E. Ann. Surg., 1923, 77: 513.
2. Hatfield, Geoffrey. Brit. J. Surg., 1925, 13: 742.
3. Keynes, G. Brit. J. Surg., 1925, 48: 663.
4. Lee, B. J., and Adair, F. E. Ann. Surg., 1920, 72: 188.
5. Idem. Surg., Gynec. & Obst., 1922, 34: 521.
6. Idem. Ann. Surg., 1924, 80: 670.
7. Levin, J. J. J. M. Ass. South Africa, 1931, 5: 552.
8. Menville, John G. Am. J. Cancer, 1935, 24: 795.
9. Rowntree, C. Lancet, 1925, 11: 1065.

AN IMPROVED, RADICAL TECHNIQUE FOR REPAIR OF HYDROCELE TESTIS

MONROE WOLF, M.D., F.A.C.S., New Orleans, Louisiana

THROUGH some years of observation and experience in the radical repair of hydrocele testis, the author has endeavored to determine the cause of the marked postoperative swelling and induration to be found in these cases. This complication occasions prolonged hospitalization (not less than 10 days) notwithstanding meticulous postoperative care by elevation of the scrotum and the application of cold or heat. A suspensory of sufficient size is unobtainable.

As so little trauma is caused by the enucleation of the sac and testis, in the Wyllys Andrews (bottle operation) technique (2), or the numerous procedures described by Bickham, it is reasonable to conclude that in the uncomplicated (non-infected) cases, there must be some disturbances in the circulatory and lymphatic systems, sufficient to cause the marked reactions encountered. Muschat's work on "Testicular Torsion" would seem to corroborate this idea, as does later work by McKenna and Ewert on "Management of Undescended Testis."

In 1932, the author began experimentation with radical procedures, incompletely enucleating the sac and testis by freeing only the anterior half or two-thirds of the sac, without detaching the gubernaculum.

The following technique was finally adopted: (1) The sac is partially separated from the fascial planes and opened to evacuate the contents. Fig. 1a—the dotted lines mark the portion of the anterior wall in process of excision. (2) Interrupted, interlocking, figure-of-eight sutures are placed around the edges, their ends being grasped in forceps and the sutures not being tied until all have been placed around the whole cut edge of the sac (Fig. 1b). These figure-of-eight sutures act as hemostatic agents and when properly tied contract the sac wall about the epididymis and posterior surface of the testis. When the figure-of-eight sutures are tied, the one at the lower pole of the testis (gubernaculum) is tied first, then that on each side, alternating until all sutures have been tied. An assistant should make slight pressure against the testis through the posterior scrotal wall in order to elevate the testis during the tying of the sutures. (3) Figure 1c illustrates the appearance of the incomplete repair of the sac wall with traction forceps on the lower mesial portion. The infundibular (deepest) fascia is noted with tunica (sac wall) in the partially tied figure-of-eight suture. (4) The dartos and skin are closed with a continuous, running suture (Fig. 1d). More recently a continuous mattress suture has been used for the skin closure. Hemostatis is essential for success, notwithstanding the fact that only an occasional ligature is required in the dartos. Plain No. 0 catgut is used throughout.

Local infiltration with novocain solution, ½ per cent was discontinued after the first 6 cases because of the edema in the scrotal wall, although there was no induration or swelling of the testis. Tutocain, 50 milligrams boiled in 2 cubic centimeters normal saline solution, as a spinal anesthetic, was next used with gratifying results. More recently an epidural injection of novocain, 2 per cent, 20 to 30 cubic centimeters has been used with much less risk. In one of the early cases, in a child, in which interrupted hemostatic mattress sutures and not figure-of-eight sutures were used under ethylene anesthesia, recurrence was reported.

In the uncomplicated cases, under spinal, epidural or gas anesthesia, a medium sized suspensory may be applied and the patients may be allowed out of bed, and be discharged from the hospital in 36 to 72 hours after operation without induration or swelling of the testis.

In 28 cases in which the interrupted, interlocking, figure-of-eight sutures were used, 19 replies report no recurrences. One patient reporting "partial" recurrence, has since been examined and no indication of fluid in the scrotum was found. One subsequent report has been received showing no recurrence, giving a total of 20 replies to 28 questionnaires without a single recurrence.

The author has had the opportunity to explore one of his first cases, operated upon by this procedure 4 years previously. On this occasion the patient presented large, bilateral masses in the scrotum which were irregular, firm, and nodular, and which transmitted light. The masses proved to be spermatoceles. It was very interesting to

From the Urologic Service, Charity Hospital, Touro Infirmary, and New Orleans Women's Hospital.

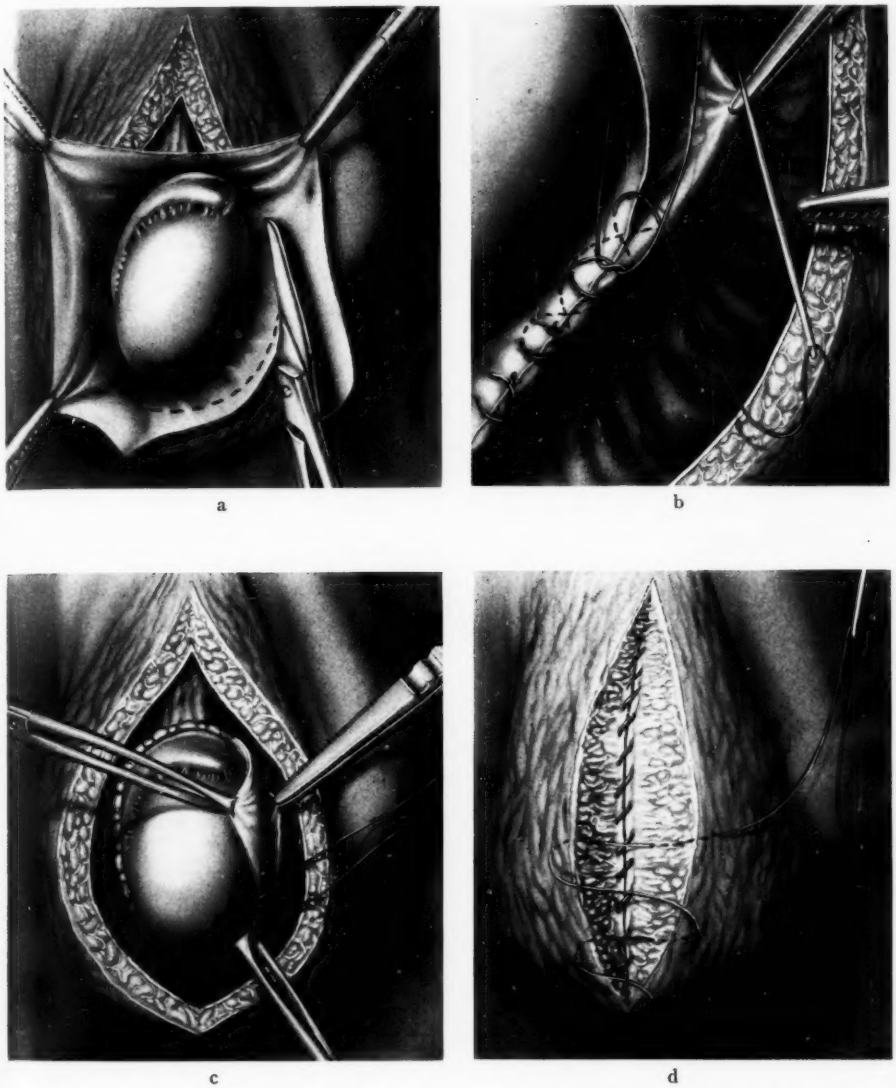


Fig. 1. a, Anterior half of sac exposed. b, Interrupted interlocking figure-of-eight sutures in sac wall. c, Appearance of repair of sac wall. d, Closure of dartos layer of skin.

note the result of the previous hydrocele repair. The surface of the tunica vaginalis was smooth and glistening, with considerable thickening behind the testis, where it had been drawn along the vas and lower end of the cord.

SUMMARY

1. A new, radical technique for repair of hydrocele testis is reported.

2. Epidural or spinal anesthesia is preferred for adults.

3. Following exposure and excision of the anterior half or two-thirds of the sac, interrupted, interlocking, figure-of-eight sutures are applied to sac edges. The dartos and skin are closed with continuous sutures.

4. Patients are able to walk out of hospital, wearing medium-sized suspensories, within 36 to 72 hours after operation.

5. In a series of 28 cases, 20 questionnaire replies, including 1 case explored 4 years after operation, show a perfect result.

The author wishes to express his profound appreciation to Mr. W. Branks Stewart, artist, Louisiana State University Medical Center, for the drawings; and to Miss Marigayle Hopkins, Social Service Department, Charity Hospital, for her interest in the questionnaires reporting results.

REFERENCES

1. BICKHAM'S OPERATIVE SURGERY. 1924, 5: 801–813.
2. KEEN'S SURGERY. 1908, 4: 607.
3. MCKENNA and EWERT. J. Am. M. Ass., 1935, 105: 1172–1175.
4. MUSCHAT. Surg., Gynec. & Obst., 1932, 54: 758–763.

FOLLOW-UP OF HERNIA REPAIR

ALFRED B. LONGACRE, M.D., New York, New York

REPORTS of the results of the operative treatment of hernia from hospitals and surgical clinics are frequently seen in the surgical journals. Preceding the last quarter of the nineteenth century, the recurrence of hernia following operation was the usual result. Halsted (17), in a paper quotes from an article written by Bull in 1890, "at this time two methods of repair are being used with nearly equally poor results." Bull, from 1883 to 1885, operated for the cure of hernia by what he called Socin's method, namely ligature and excision of the hernial sac; and from 1885 to 1889 he employed Bank's method which consisted of ligature and excision of the sac plus suture of the pillars of the external ring. Recurrences were noted in 27.27 per cent of the cases repaired by Socin's operation and in 40 per cent of those treated by Bank's procedure. These recurrences were all noted in the first year after operation. In 1890 Halsted (15) reported the operation which now bears his name. This paper was shortly followed by a similar article by Bassini (2) and in 1895 Ferguson (10) summarized the methods of surgical procedures for the cure of inguinal hernia which were in favor at that time. He also gave his modifications of the Bassini and Halsted techniques and in the same paper reported a technique for the cure of femoral hernia. Since the publication of these papers the reported incidence of recurrence of hernia has been fairly uniform; ranging from a low of 1 per cent at the Mayo Clinic (22) to figures covering a fairly wide range above this. With Bassini's and Halsted's procedure as a groundwork operators have at various times introduced modifications and changes in the detail of the technique. These changes have met with indifferent success. Bloodgood in a review of cases done with the Halsted technique reported recurrence of 5.2 per cent. Since this early report very few summaries have shown much if any improvement.

From the Department of Surgery of the Presbyterian Hospital and of the College of Physicians and Surgeons, Columbia University.

The cases in this report are those in which operation for the cure of hernia was done in the First and Second Surgical Divisions in the Presbyterian Hospital in New York City. Only those cases with a follow-up by examination of patients in the Vanderbilt Clinic will be included in an analysis of the statistics. Private and semi-private cases are excluded as their follow-up data are very incomplete and in many instances entirely lacking. The types of hernia discussed are inguinal, femoral, umbilical, and epigastric. Ventral, incisional or postoperative hernias are not included.

It is important to know the method employed in following the cases after discharge of patient from the hospital to evaluate correctly postoperative results. Many writers fail to mention the system of checking their cases, while others apparently include written reports either from the patient or some outside physician. The inaccuracy of this latter method is clearly shown in a series which reports a recurrence of 3.4 per cent in the cases followed by letter as against an 8.3 per cent recurrence in the patients which were examined in their own follow-up clinic. With such

discrepancies occurring it is obvious that the only reliable method of obtaining accurate information of the end-results of herniorrhaphies is by adequate and complete examination of the patient.

All of the patients treated in the wards of the Presbyterian Hospital are, upon discharge, given an appointment to return to the follow-up division of the Vanderbilt Clinic, which is the outpatient department of the hospital. Here, they are interviewed and examined with three main objectives in mind: anatomical result, symptomatic result, and economic result. Accordingly the findings of each of the three points are given a score ranging from 1 to 4; a 444 result being the highest possible. The patients in this series were in most instances examined by the surgeons who performed the operation. This, however, was not always possible; consequently many of the patients were checked by more than one surgeon. With the exception of instances in which it is important to include those who failed to keep their appointments in the follow-up clinic, only the patients so followed are included in the analysis of the figures. For convenience and to avoid confusion, all hernias, irrespective of complications which would give them a lower score, will be designated as a 444 result in the tables and elsewhere, unless there is recurrence, in which case it will be scored as either "recurred" or "rec" instead of the usual 044.

This series includes 752 patients operated on for hernia during the 6 year period between January 1, 1930, and December 31, 1935. These patients are all adults as those under 12 years of age are operated on in the Babies Hospital. A total of 925 hernias were repaired, all but 88 of which returned for follow-up examinations: 827 were seen at least once; 589, or 72.3 per cent, returned over a period of 12 months; and 338, or 41.5 per cent were followed at least 24 months. Sixty-six, or 8.2 per cent, of the hernias have a follow-up period of 5 years or longer. In this series the postoperative interval between repair and the time of recurrence is somewhat longer than those given in other reports. Judd found that 70 per cent of his recurrences were noted in the first 6 months and 90 per cent in the first 12 months. Erdman, in 1923, reports that 73.9 per cent of his recurrences took place in the first 12 months and 98.6 per cent in the first 24 months. In our cases 72 per cent of the recurrences were noted at the end of 12 months and 87.2 per cent of the recurrences within the first 24 months.

The surgical procedures in these cases were performed by 60 different surgeons, 38 of them being the senior house officers serving their last 4 months as interne, the 22 remaining operators being members of the attending staff. The senior house officer is assisted by a member of the attending surgical staff in every operation. In comparing the two groups of operators it was found that the cases operated on by the attending surgeons had a 6.3 per cent recurrence as against a 6.8 per cent recurrence in those repaired by the members of the house staff.

The difference in the percentage of recurrence as related to the type of anesthesia used in the operation is very small: general anesthesia, 7 per cent; spinal anesthesia, 7.5 per cent; local anesthesia, 8 per cent. In 9 cases the anesthesia record was not on the chart. It is interesting to note 2 recurrences in this group. In his report, Taylor found the incidence of recurrence higher in those cases repaired with local anesthesia, adding that a local anesthetic does not interfere with or delay wound healing. Davis reports the low figure of 2.3 per cent recurrence in hernias repaired with local infiltration or nerve block anesthesia.

That the operation for hernia carries a minimal risk of fatality is probably very true. Taylor, in 1920, reports 2,486 cases of inguinal hernia with 19 deaths, or 0.76 per cent. Davis reports 8 deaths in a series of 1,756 for a 0.44 per cent mortality; while Erdman reports a low mortality of 0.32 per cent. In this series there were 10 deaths in 752 patients which gives a 1.3 per cent mortality. In the simple or not strangulated group there were only 5 deaths, or 0.69 per cent, as against 17.8 per cent in the strangulated group. Eight of the 10 deaths occurred in patients over 50 years of age, the 2 others being in patients of 35 and 38 years of age. Eight of the patients died after the tenth day; 2 on the twenty-third day, both of which had been transferred to the medical wards, one in cardiac decompensation, the other following repeated coronary attacks. There are 4 cases of acute hernia which had been strangulated 24 hours or longer, 3 of which had to have intestinal resections. Some of the complications noted as contributory factors interfering with recovery are: cardiorespiratory failure, 1; coronary occlusion, 1; cardiac insufficiency, 1; ileus, 1; pancreatitis, 1; gastro-intestinal hemorrhage, 1; peritoneal abscess, 1; and pneumonia, 2.

In spite of repeated statements that the operative cure of hernia is nearly an ideal surgical procedure, in that the results are good and the mortality so low as to be negligible, the mortality statistics in this series are sufficiently high to warrant serious consideration of all factors pertaining to the general condition of the patient and

TABLE A.—RESPIRATORY COMPLICATIONS

	444	Recurred
Respiratory		
Upper respiratory infection	10	—
Cough	23	2
Pneumonia	27	2
Atelectasis	17	1
Pleurisy	3	—
Infarct, pulmonary	2	—
Massive collapse	2	—
Bronchitis	3	—
Trachectis	1	—
Pneumothorax	1	—
	89	5

TABLE B.—COMPLICATIONS OTHER THAN RESPIRATORY

	444
Other Complications are—	
Pain in scar	12
Thrombophlebitis	7
Swelling of testicle	6
Atrophy of testicle	4
Keloid in scar	1
Scrotal swelling	3
Ileo-pectioneal bursitis	1
Epididymitis	1
Painful testis	2
Hydrocele	5

a careful weighing of the benefits to be derived in the case in hand before suggesting an operative repair. It serves to re-emphasize the fact that even the simplest surgical procedures carry a sufficient risk, so that they should be advised only after considering all the facts concerned.

It has already been mentioned that the patients in this series fall into the so called adult group. It has long been known that patients of indirect inguinal hernias appear for operation at a younger age than do patients with other types of inguinal or femoral hernia. In the indirect group 65 per cent of the patients were under 35 years of age and only 26 per cent were over 45. Fifty-one per cent of the patients with direct inguinal hernias were under 35 years, while 46 per cent were over 35. The other groups of inguinal hernias, namely sliding and indirect-direct, fall into an intermediate age group.

The serology was determined in 667 patients: 30, or 4.49 per cent, had a 4 plus Wassermann reaction, 2 of which had a recurrence of their hernias. There are 257 cases in which the Wassermann reaction was either not reported or reported as equivocable. A truss was worn for 287 of the hernias; 26 of the hernias which recurred had at some time or another been supported by a truss. The percentage recurrence of those who had worn a truss was 9.3 which is slightly higher than that for the entire group. The weakening and scarring of tissues which is associated with the cases of hernia which had been supported by a truss was also noted in these cases. Two patients gave a history of having worn a truss from childhood for a hernia which was present at that time. Both these patients were later admitted for a repair of a hernia on the side opposite to that for which a truss had been worn and in neither case was a hernia noted on the side which had been treated by the wearing of a truss.

Wound infections were noted in 53 cases with follow-ups on all but 2. Most of these infections were trivial or stitch abscesses, the latter being so designated in 20 wounds. Only 2 of the infections were listed as serious. Twelve, or 2.55 per cent of the cases repaired with silk, showed some infection while 37, or 15.04 per cent of the cases repaired with catgut, were infected. Hematoma was noted in 17, or 1.8 per cent of the wounds, all but 3 of which were followed and no recurrences noted. Silk was the suture used in 11 of the cases with hematoma. This gives a 2.3 per cent of the total cases repaired with silk. Five or 2.3 per cent repaired with chromic catgut developed a hematoma.

Detail analysis of the cases repaired under local anesthesia shows some interesting facts. In 107 cases local anesthesia was used either by itself or in combination with a general anesthesia. Three deaths occurred in this group. In 83 cases in which operation was done under local anesthesia the suture material was either silk or catgut. In the 54 repaired with silk alone there were 1 infection, 4 hematomas, and 1 recurrence, while in the 59 cases repaired with catgut there were 6 infections, 4 recurrences, and no hematomas.

The frequency of other postoperative complications and their relationship to the incidence of recurrence are given in Tables A and B. The appendix was removed at the same time and through the same wound in 6 cases of right inguinal hernia, with 1 recurrence; 16 hydroceles were excised; the wall of the intestine was pierced with a needle in 2 instances; the bladder was accidentally opened in 3 cases; in 3 cases the vas was accidentally cut; 4 cases had an orchidectomy and vasectomy, and in 1 case the vas was crushed. In addition there were 2 cases of undescended testicle and 8 with the varicocele.

Of the 925 hernias, Table I, 816 belong in the inguinal group, with a follow-up on 734; 703 were in males and 86 in females, the ratio of almost 9 to 1. In the female group the hernias are divided as follows: 71 indirect, 7 direct, 2 indirect-direct, 1 sliding, and 5 in the recurrent group. There are 62 femoral hernias, all but 5 of which returned to

TABLE I.—ANALYSIS OF CASES

	Male	Female	Total	Not followed	Recurred	Died	Not followed per cent	Recurred per cent	Died per cent
Indirect	463	71	534	60	26	1	11.2	5.6	0.18
Direct	114	7	121	6	8	—	4.9	6.9	—
Indirect and direct	54	2	56	7	5	—	12.5	10.2	—
Sliding	28	1	29	2	4	1	6.8	15.3	3.4
Indirect recurrent	46	2	48	7	5	1	14.5	12.2	2.08
Direct recurrent	25	3	28	—	3	1	—	10.7	3.50
Femoral	11	51	62	5	3	1	8.0	5.4	1.6
Umbilical	2	7	9	—	—	—	—	—	—
Epigastric	7	3	10	—	1	—	—	—	—
Inguinal strangulated	13	5	18	1	1	3	5.5	5.8	16.6
Femoral strangulated	3	7	10	—	1	2	—	10.0	20.0
Totals	766	159	925	88	57	10	9.6	6.8	1.08

the clinic for examination, making a total of 57 followed cases. In the umbilical and epigastric group there are 19 cases, 9 male and 10 female. There are 28 strangulated hernias, 18 of the inguinal type and 10 in the femoral group; the male to female ratio remaining about the same as in the other groups.

The 816 inguinal hernias are divided into the 6 following groups: the indirect group of 534 hernias, with 473 followed cases, 121 direct inguinal hernias with 114 followed cases, 56 indirect-direct inguinal hernias with 49 followed cases, 29 sliding hernias with 26 followed cases, 76 combined hernias with 67 followed cases. The incarcerated hernias are included with the reducible hernias of their respective types. However, the acute or strangulated hernias are listed separately and will be discussed later. Recurrences are found in 26 or 5.6 per cent of the indirect inguinal hernias, 8 or 6.9 per cent of the direct inguinal hernias, 5 or 10.2 per cent of the indirect-direct inguinal hernias, 4 or 15.3 per cent of the sliding hernias, 8 or 11.9 per cent of the recurrent hernias.

Bilateral and double hernias occurred in 152 or 20.7 per cent of the patients. In this paper the term double hernia is limited to designate those cases of bilateral hernia in which the hernias were different one from the other on either side. There are 101 patients with bilateral hernia and 37 with double hernia. These figures do not give the correct incidence of bilateral or double hernia, for in addition there are 67 patients who had a hernia on the side opposite to that which was repaired in this series. There are also an additional 12 cases of double hernia in which one or both sides belonged in the recurrent group; 2 cases in which a double hernia was found on the same side. These last 2 cases were both direct inguinal her-

TABLE II.—SUTURE MATERIAL

	Total			Chromic catgut			Silk		
	444	Rec.	Rec. per cent	444	Rec.	Rec. per cent	444	Rec.	Rec. per cent
Indirect	447	26	5.5	156	17	9.8	272	6	2.16
Direct	107	8	6.4	19	3	13.6	85	4	4.49
Indirect and direct	44	5	10.2	12	3	20.0	32	2	5.8
Sliding	22	4	15.3	9	3	25.0	14	1	6.6
Indirect recurrent	35	5	12.5	11	3	21.4	24	2	7.6
Direct recurrent	24	3	11.1	6	2	25.0	15	1	6.2
Femoral	53	3	5.5	26	2	7.1	25	1	3.8
Umbilical	9	—	—	5	—	—	4	—	—
Epigastric	10	1	9.9	2	1	33.3	8	—	—

TABLE III.—BILATERAL HERNIAS

Bilateral hernias		One admission		Two admissions
		One operation	Two operations	Two operations
Indirect inguinal	444	46	8	9
Recurred 1 slide		4	—	2
2 slides		1	—	—
Direct inguinal		14	9	—
Recurred 1 slide		—	—	—
2 slides		1	—	—
Indirect-direct inguinal	444	2	—	—
Recurred 1 slide		1	—	—
Double inguinal	444	13	8	4
Recurred 1 slide		1	—	2
2 slides		—	1	—
Femoral	444	1	—	—
Total		84	26	17

TABLE IV.—DOUBLE HERNIA

Co-existent with	Double hernia			
	Indirect	Direct	Indirect recurrent	Direct recurrent
Indirect	—	—	2	2
Direct	7	—	—	1
Indirect and direct	7	5	—	—
Sliding	4	3	1	—
Femoral	3	4	1	—
Umbilical	1	1	—	—
Epigastric	2	—	—	—
Indirect recurrent	—	—	3	3
Direct recurrent	—	—	1	—

nias with associated femoral hernia. Table III gives the number and frequency of recurrence as found in this series of bilateral hernias. Bilateral hernia occurred 70 times in the indirect inguinal group and 24 times in the direct inguinal hernia group. There are no cases in which a sliding hernia was bilateral, but it did appear in 7 of the double hernias. Table IV separates and gives the relative frequency of double hernia and also indicates the most frequently found combinations of double hernia.

The analysis of the cases of bilateral and double hernia is divided into three groups as illustrated in Table III. Recurrent hernias are not included in this table. In the first column the patients who had both sides repaired at one operation are listed while the middle column gives those repaired at separate operations on the same hospital admission, and column three listing those who had either side repaired on separate admissions. In the first of these groups 9, or 5.3 per cent, of the hernias recurred; in the second group 2, or 3.8 per cent, and in the last group 4, or 11.7 per cent, recurred. This series is too small for definite conclusions but seems to indicate that those which were repaired at separate operations had a better prognosis.

Transverse and Judd incisions were used in 16 cases, recurrences being found in 3 of them. There were 6 wound infections in the cases of bilateral hernia which were repaired at one operation and 5 infections of those which were repaired at separate operations. Three of these infections were in cases which had recurrences of the hernia and these belong to the group in which the operations were performed on different occasions. As there are so few cases in this series of bilateral hernia, any attempt to correlate, with the incidence of infection, would only be misleading, whether or not both hernias were repaired at the same operation or at separate operations.

Suture material in hernia repair has been much discussed in the literature. The points which have been emphasized is the necessity of having a material of sufficient strength and durability to hold the wound together over a long enough period of time to allow it to heal solidly. The separation of the line of repair has been given as one of the most frequent causes of recurrences. Halsted varied his choice of suture material; however, most of his hernias were repaired with silk. He reported one series in which he used silver wire exclusively. Table II gives the number of hernias repaired with either chromic catgut or silk with the incidence of recurrences of each. This table does not include hernias which were repaired with chromic catgut and silk combined, linen or linen and chromic combined. Silver wire was used on one occasion. Irrespective of the type of hernia a marked and impressive lower incidence of recurrence is found in the cases repaired with silk as compared with those repaired with chromic catgut. In our series silk was used in 496 hernias, 3.4 per cent of which recurred; chromic catgut was used in 270 with 12.5 per cent recurrent. In the direct inguinal group 89 of the hernias were repaired with silk and 22 with chromic with 4.49 and 13.6 per cent recurrences, respectively. There were 278 indirect inguinal hernias repaired with silk and

TABLE V.—MISCELLANEOUS FACTS

	Wassermann				Transversalis fascia						Fascia strips						Truss	
	++++		Not Recorded		Repair		Suture to Poupart		Plicate		External oblique		Lata		Rectus			
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Indirect—444	19	5.6	144	29.7	54	11.2	153	31.8	83	17.2	34	7.6	15	3.2	7	1.4	121	25.1
Indirect—Rec.	1	4.5	11	36.6	4	6.9	9	5.5	8	8.7	3	8.1	5	15.0	2	22.2	15	11.0
Direct—444	3	3.0	31	24.3	13	10.1	22	7.1	49	38.2	24	18.6	21	16.3	2	1.5	70	54.6
Direct—Rec.	1	11.0	4	30.3	1	7.1	5	18.4	1	2.0	1	4.0	3	12.6	—	—	3	4.1
Indirect and direct—444	—	—	11	25.0	12	27.3	11	25.0	7	15.9	9	20.4	2	4.5	2	4.5	20	45.6
Indirect and direct—Rec.	—	—	1	20.0	—	—	1	8.3	3	33.3	—	—	—	—	—	—	1	4.7
Sliding—444	—	—	13	59.0	3	13.6	8	36.3	3	13.6	2	15.3	4	30.6	2	15.3	10	45.4
Sliding—Rec.	—	—	—	—	—	—	—	—	—	—	1	33.3	—	—	—	—	1	9.9
Total—444	22	3.4	199	30.9	82	12.1	194	30.2	142	20.1	69	10.2	42	6.2	13	1.9	221	33.7
Total—Rec.	2	8.3	16	7.4	5	5.7	15	7.1	12	7.8	5	6.7	8	16.0	2	13.3	20	8.3

153 repaired with chromic, the incidence of recurrences being a 2.16 and 9.8 per cent, respectively. The greatest difference is noted in the sliding hernias 35 of which were repaired with silk and 12 with chromic, 6.6 per cent of the silk repairs recurring and 25 per cent of the chromic recurring. The recurrences in the recurrent hernias are comparable but slightly higher than those of the simple hernias. Glenn and McBride reported a series of 500 hernias repaired with silk with the following percentage of recurrences: 2.3 in the indirect inguinal group, 6.21 in the direct inguinal group. In 1919 Masson reported 7,016 cases of inguinal hernia repaired with 20 day chromic catgut with a less than 1 per cent recurrence in the cases with cord transplantation and slightly more than 1 per cent in the cases in which the cord was not transplanted. He does not give follow-up statistics; consequently, it is impossible to determine how many of his patients were examined at the Mayo Clinic. His figure would be more impressive if he had found this low recurrence in his followed cases.

Silk as a suture material is being more frequently used in clean surgical cases. In this series twisted A or C silk or finely woven Deknatel silk was used throughout. That catgut varies in its durability and lasting qualities has been very clearly shown by Kraissl in a report on the absorption rate of catgut. In this article he also shows that there are individuals, appearing more frequently than one would expect, who are sensitive to catgut. In these cases there is a definite reaction about the sutures and in all cases of wound disruption in allergic patients in which catgut was used and the skin test for sensitivity made, the patients gave a positive reaction. He advocated the use of the skin test of all patients for sensitivity to catgut before using it. If this is done in cases of hernia repaired with catgut the difference in the incidence of recurrences as compared to the incidence of recurrence in those repaired with silk might be much less.

The hernias comprising the group repaired with suture materials other than those described are too few in number to warrant further discussion. There are three recurrences in the cases in which the choice of suture was not mentioned and two recurrences in the strangulated hernias.

The operations in this series can not be classified in the usual manner. Each operative note describes the repair specific to that case. It is, therefore, impossible to list the repair as a typical Bassini, Halsted, Ferguson, Wyllys Andrews or any other type. The remainder of the discussion of the inguinal hernias will be limited to the main points described in the operation notes.

The treatment of the hernial sac consisted of freeing it from the surrounding tissue. If adhesions were encountered these were severed by either blunt or sharp dissection which was carried as far as the internal ring. The sac was then excised and ligated and in many instances the stump of the sac was transfixed under the internal oblique muscle. There are no cases in which the sac was used as a tampon as advocated by Macewen and Ferguson.

The transversalis fascia has been considered one of the first lines of defense in the repair of hernia since the days of Halsted and Ferguson. The

TABLE VI.—TRANSPLANTATION OF CORD

Inguinal hernia	Cord under aponeurosis				Cord subcutaneous				Cord not transplanted				Cord not stated			
	444		Rec.		444		Rec.		444		Rec.		444		Rec.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Indirect	271	64.2	16	5.5	51	12.0	9	15.0	35	8.2	1	2.7	52	12.2	4	7.1
Direct	70	57.5	2	2.7	35	29.1	6	14.6	2	1.6	—	—	13	10.8	3	18.7
Indirect and direct	17	38.6	3	15.0	12	27.2	1	7.6	2	4.3	—	—	7	15.9	—	—
Sliding	13	61.9	1	7.1	6	28.5	21	14.2	—	—	—	—	2	9.5	1	33.3
Total	371	61.0	22	5.6	104	17.1	18	14.8	39	6.4	1	2.7	74	12.1	8	9.7

usefulness of this layer varies greatly with individuals. It is frequently so thin that it is of little value while in other cases it is difficult to define it as a separate layer. Anatomically it is easy to understand the importance in the treatment of this layer of tissue as it forms the first and probably the most important line of defense against recurrence. However, stress should be laid on the repair of this fascia in the region of the internal ring for it is in this region that this fascia is the weakest and consequently the site of most recurrences. The triangle formed where this fascia allows the cord and its structures to emerge from the abdominal cavity should be very carefully repaired. Elsewhere one of the following three methods which will be mentioned can be used to strengthen this layer of fascia deep to the cord.

This fascia was used in 450 hernias with 32, or 7.1 per cent, recurrences. It was used in one of the following methods: suture of the fascia to Poupart's ligament, and plication. The effectiveness of the use of the fascia is tabulated in Table V. From this it can be seen that it did not materially lower the incidence of recurrences in those cases in which attention was paid to the transversalis fascia. In the indirect inguinal group suturing of the transversalis fascia to Poupart's ligament seemed to be most effective with only 9 or 5.5 per cent recurrence, while in the direct group of hernias those in which the fascia was plicated there was only 1 or 2 per cent recurrence. It is very difficult from this series to come to any conclusion as to the value of the use of the transversalis fascia in preventing recurrences in inguinal hernias. If the operative notes had described in detail the treatment of this layer of tissue at the internal ring, a more detailed and critical analysis could have been made. In this connection it is interesting to note that in the cases in which the treatment of the transversalis fascia was not mentioned, there were only 19, or 6.9 per cent, recurrences, a figure which is slightly lower than that in which the fascia repair was used.

In practically every instance the conjoined tendon and the lower border of the internal oblique muscle was sutured to the shelving margin of Poupart's ligament. Those cases in which the conjoined tendon was either obliterated or too narrow to make its use effective will be discussed under the living fascia sutures.

Halsted and Bassini simultaneously described transplantation of the cord as an important step in hernia repair. In Bassini's operation this was transplanted to lie immediately beneath the aponeurosis of the external oblique muscle. Halsted transplanted the cord subcutaneously in his early cases, later modifying the position according as he found the pathology. Table VI gives the frequency of cord transplantation with the incidence of recurrence. In 393 hernias it was left under the external oblique and in 122 hernias it was placed superficial to this structure. Included in the instances in which it was left subcutaneously are a few cases in which it was left between the leaves of the imbricated margins of the aponeurosis as described by Wyllys Andrews. Transplanting it under the external oblique was most effective in the cases of direct inguinal hernias with the recurrence of 2.7 per cent. The group of hernias in which the cord was placed to lie subcutaneously had in all but one group a higher incidence of recurrence than in those cases when it was left under the external oblique. There are only 40 cases in which it was definitely stated that the cord was not transplanted, 35 of which were indirect inguinal hernias, 1 of which recurred. In 82 cases the treatment of the cord was not mentioned. In 2 cases the cord was treated much after the manner described by Torek (27) with separation of the vas from the veins of the cord; in neither was there recurrence. Blood-

good's procedure of excising the veins was performed in a few cases. This was limited to the cases in which the spermatic cord was unusually large. The treatment of the cord was not stated in most of the operative notes of the recurrent hernias. The cases in which the cord was excised with orchidectomy are listed elsewhere.

Living fascial sutures were used in 139 hernias. In 74 cases the suture was taken from the lower margin of the aponeurosis and in 50 a strip of the tensor fascia femoris was used. In 15 cases a strip of either the rectus muscle or fascia was used to strengthen the medial angle of the repair. The use of the rectus fascia was limited to those cases in which the conjoined tendon was either obliterated, narrow, or so frayed that it was of little value. Recurrences were noted in 5, or 6.7 per cent of the cases repaired with a strip of the external oblique aponeurosis; in 8, or 16 per cent of the cases repaired with fascia lata, and in 2, or 13.3 per cent of those in which the rectus muscle or fascia was used. Fascia lata was used more frequently in the cases of recurrent hernia; this may possibly explain the higher incidence of recurrence in this group. In many of the cases in which repair was done with fascial sutures and there was recurrence the operative note describes the previous fascial repair as being satisfactory.

Sliding hernia were found in 3.1 per cent of the series. This is a somewhat lower incidence than noted in other papers. The viscera found in these hernias are: cecum, 5 times; bladder, 4; and sigmoid, 9. In 2 of the cases the bladder was accidentally opened. There were 76 recurrent hernias with 11.9 per cent recurring. This figure is lower than reported in other papers.

In the group of 72 femoral hernias, 10 were strangulated, 4 recurred, and 3 patients died; 5 patients failed to return to the follow-up clinic and are omitted from this discussion. Thirty-six of the hernias were repaired through incisions made below Poupart's ligament; 18 from incisions above and paralleling the ligament; 4 so called vertical incisions, all of which probably belong to the first group; 5 combined incisions which ran from below up and lateral across the ligament; 3 rectus incisions; and in 6 cases the position of approach was not clear. Bassini's technique of suturing the pectineal fascia to Poupart's ligament was done in 37 cases. The other repairs were done as follows: in 2 cases Poupart's and Cooper's ligaments were brought together; 3 cases in which the defect was closed with a purse-string suture; 3 in which the defect was closed from within the abdomen and in 12 the method of repair was not stated in detail. Recurrence was noted in 1 case in which repair was done by suturing Poupart's ligament and the pectineal fascia together; the 2 other recurrences in the group were in the cases in which repair was not clear. There were 10 strangulated and 30 irreducible hernias in this group; 2 of the strangulated hernias were of the Richter type.

The mortality analysis of the strangulated hernias has previously been discussed. That femoral hernias strangulate more frequently than inguinal hernias is a well known fact. This was also noted in this series, there being 10 strangulated femoral hernias in 72 cases as compared to 18 strangulated hernias in the larger inguinal group. In 5 of the 28 cases the intestine had been compromised to such an extent that resection was imperative. In each case it was the small intestine which was resected. Duration of acute symptoms preceding operation varies from 3 hours to 5 days, the greatest number presenting themselves within 20 hours of onset. In those patients who died the hernia had been strangulated 24 hours or longer. The 3 patients requiring resection died; all 3 had had symptoms longer than 48 hours.

As there are only 9 cases of umbilical hernia and 10 cases of epigastric hernia only a little valuable information can be gained from their analysis and consequently they will be discussed together. There were 2 cases of umbilical hernia in the male and seven in the female, while in the epigastric group 7 were in males and 3 were in females. Only 2 of the umbilical hernias were in patients under 35 years; 4 patients were between 36 and 45 years with 1 occurring after the 45th year. The age incidence in the epigastric group is almost identical and will not be repeated. The technique of horizontal overlap as described by Mayo was used in 6 cases of umbilical hernia, the 3 others being repaired by simple approximation of the edges of the defect. Six of the epigastric hernias were also repaired by approximating the edges of the defect without an attempt at either a vertical or a horizontal overlap. Silk was used in 8 cases of epigastric hernia and only once in umbilical hernia. Chromic catgut sutures were used in 7 cases of umbilical hernia and in only one of the epigastric hernias. Kangaroo tendon was used once as well as chromic and silk. There was one infection in the umbilical group, and three of these patients were drained. All of the wounds in the epigastric hernias healed *per primam*. One of the epigastric hernias recurred.

SUMMARY AND CONCLUSIONS

In concluding it might be stated that the purpose of this review is to summarize our cases of

hernia and to present the incidence of recurrence and of certain factors as they were found in the cases which did not recur as well as in those which did recur. A complete metamorphosis in hernia repair took place following Bassini's and Halsted's papers describing their techniques which today are still the most satisfactory and have been changed but little since the publication of their articles.

The difference in the incidence of recurrence in all types of hernias repaired with silk as compared to those in which chromic catgut was used is very striking. Studies, which are now being made, indicate that the failure in those cases in which repair was accomplished with chromic catgut, can partly be explained as being due first to a defect in the suture material; second, variability of the absorption rate; and third, patient's sensitivity to catgut.

Better results were obtained in those cases in which the cord was left under the external oblique aponeurosis.

This series of cases re-emphasizes the fact that if a technique can be so elastic as to meet the variations, anatomical and pathological, found in hernias, the perfect hernia repair is yet to be described.

BIBLIOGRAPHY

1. Andrews, Edward Wyllys. A plastic operation for hernia; umbrication or lap-joint method. Chicago Med. Rec., 1895, 9: 67.
2. Bassini, Edvardo. Novo metodo per la cura radicale dell'ernia Inguinale. Atti d. Cong. d. Ass. med. ital., 1887, Xii Pavia; 1889, 11, 179; 1889, Pavia.
3. Idem. Ueber die Behandlung des Leistenbruche. Arch. f. klin. Chir., 1890, 40: 429.
4. Bloodgood, Joseph C. The transplantation of the rectus muscle in certain cases of inguinal hernia in which the conjoined tendon is obliterated. Johns Hopkins Hosp. Bull., 1898, 9: 96.
5. Bull, William T., and Coley, William B. Observations upon the operative treatment of herniæ at the Hospital for the Ruptured and Crippled. Ann. Surg., 1898, 28: 577.
6. Idem. Report of 2000 operations for the radical cure of hernia performed at the Hospital for the Ruptured and Crippled from 1890 to 1907. J. Am. M. Ass., 1907, 49: 1017.
7. Davis, Lincoln. Complications and sequelæ of the operation for inguinal herniæ. J. Am. M. Ass., 1916, 67: 480–483.
8. Erdman, Seward. Inguinal hernia in the male with regard to the late operative sequelæ. Ann. Surg., 1917, 66: 702.
9. Idem. Inguinal hernia in the male (late results in 978 traced cases). Ann. Surg., 1923, 77: 171.
10. Ferguson, Alexander Hugh. On the radical cure of inguinal and femoral hernia by operation. Am. J. Surg., 1895, 21: 547.
11. Idem. Oblique inguinal hernia; typic operation for its radical cure. J. Am. M. Ass., 1899, 33: 6.
12. Idem. The technique of modern operations for hernia. Chicago, 1907.
13. Foster, George V. The use of fascia lata in the repair of hernia. Surg., Gynec. & Obst., 1936, 63: 632.
14. Glenn, Frank, and McBride, Andrew. Surgical treatment of 500 hernias. Ann. Surg., 1936, 104: 1024.
15. Halsted, William S. The radical cure of inguinal hernia. Johns Hopkins Hosp. Bull., 1889–1890, 1: 12.
16. Idem. The radical cure of inguinal hernia in the male. Am. J. Surg., 1893, 17: 549.
17. Idem. The operative treatment of hernia. Am. J. M. Sc., 1895, new series Cx 13.
18. Idem. The cure of the more difficult as well as the simpler inguinal hernia. Johns Hopkins Hosp. Bull., 1903, 14: 208.
19. Judd, Edward S. Inguinal hernias—type of operation—end result in 1652 cases. J. Minn. M. Ass. & Northwest. Lancet, 1908, 28: 65.
20. Kraissl, C. J. Intrinsic factors altering the absorption of catgut. Surg., Gynec. & Obst., 1936, 63: 561.
21. Lusk, William. Rectus transplantation by a special technique. Ann. Surg., 1913, 58: 675.
22. Masson, James C. Recurring inguinal hernia. Minnesota Med., 1919, 11: 373.
23. Mayo, William J. Umbilical hernia. Ann. Surg., 1901.
24. Idem. Further experience with the vertical overlapping for the radical cure of umbilical hernia. J. Am. M. Ass., 1903, 41: 225.
25. Taylor, Adrian S. The results of operations for inguinal hernia. Arch. Surg., 1920, 1: 382.
26. Torek, Frans. Combined operation for the removal of the appendix and the cure of the right inguinal hernia. Am. J. Surg., 1906, 43: 665.
27. Idem. A contribution to the study and surgical treatment of oblique inguinal hernia. Med. Rec., 1912, 81: 1174.

EDITORIALS

SURGERY
Gynecology and Obstetrics

FRANKLIN H. MARTIN
Founder and Managing Editor
1905–1935

LOYAL DAVIS, EDITOR

Associates
SUMNER L. KOCH MICHAEL L. MASON

DONALD C. BALFOUR, *Associate, Editorial Staff*

FEBRUARY, 1939

CONTROLLING OPERATING ROOM STERILIZERS

IT will probably come as a surprise to some, if not to many, surgeons that today, nearly a half century since the advent of aseptic surgery, materials frequently are delivered to the operating room which, from the nature of the procedure of sterilization, could not properly be considered sterile.

A number of items enter into the reasons for this unfortunate and even dangerous situation. In the first place, there is no clearly established rule for deciding what personnel should do the sterilizing and one sees this important process carried out by persons ranging from janitors and busboys, through a changing personnel of student nurses, to experts employed to do nothing but sterilize hospital goods. Many persons who sterilize these supplies have not the slightest notion of the fundamental principles involved nor even rudimentary knowledge of the mechanical equipment used. A second reason is to be found in the equipment, not necessarily the apparatus itself but its state of repair. One extreme case recently was noted wherein for days no steam had entered the sterilizer because of a plugging of the steam valve, the nurse not having noted the failure of the gauge to register. A third factor, and probably the most important from the practical standpoint, is failure to appreciate the obvious fact that the pressure gauge is a safety device to help prevent explosion and that the important factor so far as sterilization is concerned is temperature. In this connection few seem to know that a mixture of steam and air reduces the temperature without affecting the pressure and that only in the presence of pure steam is the proper pressure-temperature ratio maintained. To obtain an atmosphere of pure steam requires thorough exhaustion of the chamber and this directs attention to a fourth reason for lack of sterilization; namely, that manufacturers frequently have not provided adequate means of exhausting the air and condensed steam from the inner chamber. The by-passes are frequently small and easily plugged with débris or lime. Far better is it to open the door and let the steam flow freely into the room at the beginning than to fail to exhaust the chamber at the end. The use of a vacuum is begging trouble for this tends to suck in air through any small leak. It is far better to exhaust air by steam pressure than by air vacuum. A fifth factor is found in the practice of overloading the sterilizer with materials, especially in tightly packed packages. This precludes the ready access of steam to the materials and causes great variation in the time-temperature ratio in individual packages, making it necessary to exceed the required time for running the sterilizer in order to assure sterilization. It must

be constantly remembered that the penetration of steam into packages varies with the nature of the material, their positions in the chamber, and the tightness with which they are packed.

The important point is to be sure that each piece of material has been submitted to adequate temperature for an adequate time. Unfortunately there is no universal agreement on this matter. How short a time may be considered acceptable to some may be seen from recent specifications submitted by one bureau calling for devices which will indicate "sterilization" at 250 degrees F. for not less than 5 minutes and not more than 6 "in a light surgical pack." While it is questionable if this is enough time even for test tube experiments, it clearly gives no margin of safety, which certainly should be at least thrice the time required and some would advocate more. While the exact time-temperature relationship may be considered of academic interest only, it is clear that whatever it is one should know that materials have been submitted to a predetermined temperature for a predetermined time. This can be known only by the use of some reliable indicator of which there are three types.

The first of these indicators is a recording temperature clock. This is a positive device and the bulb of the thermometer should be placed in the exhaust steam line. The instrument is expensive and troublesome and does not necessarily give the temperature of the inside of a typical package. Relatively few sterilizers are equipped with the device or are likely to be.

The second device is a glass tube in which a chemical of fixed melting point is sealed. If these tubes are tested in an oil bath, the chemical melts in a few seconds at 250 degrees F. or even at lower temperatures. It is assumed by some that when these tubes are placed in gauze packages they act as lag thermometers. The time of lag is certainly variable and under no circumstances does the chemical take longer than a few minutes to melt. If there is any margin of safety at all it is slight and, under many conditions, the chemical melts before the minimal time and temperature have been maintained. If these tubes are used, several should be employed in each load and they should be employed with full knowledge of their obvious limitations and of the expense involved.

Finally there are the ink indicators, which are fixed as to the relation of time and temperature and must be submitted to moist heat for a given time at a given temperature before a change of color occurs. One such indicator has several inks on it, which turn at five minutes, twelve and a half minutes, twenty minutes, and more than twenty-five minutes, respectively. These are reliable, sharp at end point, and permit one to know the exact condition under which the sterilization has been accomplished. If one of these devices is inserted in a pack which is then placed at the "coldest" place in the sterilizer, one may be assured of adequate sterilization if the ink has turned. The margin of safety desired can be readily controlled. Certainly if the twenty-minute ink has turned, the margin is fully adequate and the few extra minutes will not cause any great inconvenience. For rubber gloves, which have first been adequately prepared before autoclaving, twelve and a half minutes is sufficient. The total length of time the sterilizer will need to be steamed will vary with the particular conditions attending the procedure.

More recently an entirely new device has been invented and used. This consists of a time clock which will not permit the door of the sterilizer to be unlocked until a certain temperature has been maintained for a cer-

tain length of time. The expense and intricacy of the device, the fact that it is marketed at present by only one firm, and will not routinely test the condition of individual packs, will naturally limit its use.

What is urgently needed is for some responsible body to set up standards for these sterilizer controls, for there is much difference of opinion now as to the necessary time-temperature ratio. Whatever ratio is agreed on it should carry with it a margin of safety adequate to cover all the usual slips in technique. The indicator should be required to have a controllable lag time, a sharp end point, and to be stable, easily used, and cheap. It will be desirable to have to use only one indicator to the load. No better standardizing body could be suggested than the American College of Surgeons and the importance of the matter would justify its attention to this problem.

T. B. MAGATH.

THE ENDOMETRIAL BIOPSY

IT is interesting that the term "biopsy" has come to mean to some a method of obtaining tissue for examination. It is essential that the term be understood to refer to the diagnostic (usually microscopic) examination of a piece of tissue removed from a living subject. Examination of the tissue and the information thus gained are, of course, the significant features. The term has nothing to do with the method employed to obtain tissue nor with the type of instrument used. When the term "endometrial biopsy" is used herein, therefore, it implies that the tissue may be obtained either by diagnostic dilatation and curettage or by means of any instrument with which satisfactory endometrial specimens can be obtained. Since the information gained by the proper examination and interpretation of endometrial findings is one of the features requisite for the intelligent management of menstrual dysfunctions, it seems justifiable to restate briefly some of the helpful steps in this procedure.

It becomes increasingly evident that far more information can be obtained from such a diagnostic procedure than mere exclusion of a malignant process which in itself is, of course, important. Until the last few years, however, in that large group of cases in which no malignant change was encountered, the tendency was prevalent to label all of these non-malignant tissues as hypertrophied or hyperplastic endometrium. It is known now, however, that the microscopic appearance of the endometrium holds the information so essential to the proper interpretation of ovarian function regardless of whether the function is normal or abnormal. Endometrial biopsy has limitations, however, in that it fails to give the information necessary to allow the dysfunctions to be classified on a basis of etiology. This merely means that the reflection of the ovarian disturbance in the endometrium is the same, regardless of whether the cause of the ovarian disturbance comes from within the ovary (primary ovarian deficiency) or whether the cause of the disturbance in the ovary is secondary to disturbed physiologic function of the pituitary or thyroid glands which so definitely control ovarian activity (secondary ovarian deficiency). Endometrial biopsy, however, has proved to be the greatest single aid in determining whether the ovarian deficiency is partial or complete.

It is known, not only from clinical observation but also from the brilliant experimental studies of those concerned with these problems, that the regenerative phenomena which occur monthly in the endometrium are controlled by the action of the normal output of the estrogenic principle, a product of the follicle, and that the differentiation of this

tissue into a functioning unit is directly dependent on the action of the product of the corpus luteum, progesterone. The recovery of progesterone from urine of women was delayed for a considerable period. The explanation of this lies in the fact that the product of the corpus luteum, unlike the product of the follicle (estrogen), is excreted as a changed compound to which has been given the name pregnandiol. To Venning and her associates is credited this excellent observation which has recently been confirmed by Wilson, Randall, and Osterberg. Before isolation of this product it was possible, however, by observation of the endometrial histologic characteristics, to predict the almost exact time of appearance in the urine of this recently isolated material. The prediction, of course, was made by observing the changes in the histologic pattern of the endometrium which follow almost immediately the period of initial activity of the corpus luteum.

Endometrium is the only human tissue in which study of regeneration has been possible. Regeneration of endometrium, just as is true of regeneration of any tissue, follows a definite histologic course of events. From observations of this process have come the interpretation of abnormal ovarian activity in terms of what normally occurs in regeneration. The first half of the regenerative process (menstrual cycle) consists in active proliferation of the tissue and this proliferation is controlled entirely by the action of estrogen, the product of the normally functioning follicle. As has been stated, differentiation of the endometrium into a functioning tissue depends on the principle of the corpus luteum, progesterone. It follows, then, that irregularity in the functional balance of the ovarian hormones which control this process is followed by irregularity in the regenerative phenomena controlled by these hormones. This, in turn, results in menstrual dysfunction: either bleeding, amenorrhea or sterility. If, therefore, the intention is to learn something concerning the activity of these hormones on the endometrium, tissue for study never should be obtained, either by instruments designed for office purposes or by dilatation and curettage, until the normal period of activity of these hormones on the endometrium has passed. For example, the information desired from examination of this tissue will not be obtained if specimens are removed from the uterus in the first half of the menstrual cycle (proliferative phase) regardless of whether the cycle is normal or abnormal. Normally, regenerative phenomena will have reached completion about twenty-five days after onset of the last period of bleeding. If, therefore, a disturbance of the regenerative process, as manifested by a persistently proliferative type of endometrium, is found on the twenty-fifth day, when differentiation should be nearly complete, then the desired information has been obtained, namely, that there has been a failure of luteinization. Specimens for study, therefore, always should be taken around the twenty-fifth day of the cycle, regardless of whether the cycle is considered normal or abnormal; that is, the specimen should be removed twenty-five or more days after onset of the last period of bleeding.

Another significant feature of the problem lies in the fact that often, in examination of removed tissue, a study mistakenly is made of the basal layers of the endometrium. This will not afford information of value since the basal layers remain the same throughout the cycle. Therefore, the section of tissue studied always should contain the surface epithelium for it is from this portion of the tissue that the regenerative process is carried on. If the procedures mentioned are followed, often it is possible to determine the clinical syndromes associated with certain endometrial patterns. For exam-

ple, Randall and Herrell recently reviewed 278 cases of ovarian dysfunction in which cystic changes occurred in the endometrium. Classifying these tissues on the basis of the regenerative phases mentioned, they found that the greater the tendency toward differentiation, which is a function of the corpus luteum, the smaller the tendency toward bleeding dysfunction, while the tendency is greatest toward sterility. On the other hand, when these cystic changes were associated with arrestment of the regenerative process in the proliferative phase of the cycle (corpus luteum deficiency), the tendency was greatest toward bleeding dysfunction and to a lesser degree toward sterility.

It is further interesting that study of this remarkable regenerating tissue has recently led to the observation that cancer of the endometrium nearly always is associated with a certain type of endometrial pattern, namely, a persistently proliferative type of endometrium which denotes the presence of the estrogenic principle but lack of the differentiating power of the luteinizing factor. Absence of any evidence of malignancy in the endometriums of patients previously subjected to oophorectomy is somewhat startling. These observations seem pertinent in view of the growing evidence for the carcinogenic tendency for estrin and estrin-like preparations.

WALLACE E. HERRELL.

ACROSS THE EDITORIAL DESK

IT is given to few surgeons to enunciate *principles of surgical treatment* but Philibert-Joseph Roux who spent the active years of his surgical life in the Hotel Dieu in Paris, where he lived from 1780–1854, stated such a principle which has become a law. In substance he said that functional pressure permits the formation of bony callus but tension or shearing forces inhibit the formation of callus and stimulate the production of fibrous connective tissue. Almost 100 years later, Pauwel described the reclination method of the physiological reconstruction of non-united fractures of the neck of the femur and his idea is based entirely upon the law enunciated by this same Roux. KARFIOL of San Francisco uses Pauwel's method and describes the advantages not found in other procedures. Of course, there are few subjects about which there is so much discussion and in the treatment of which there are so many different methods as fractures of the neck of the femur.

PERHAPS you will not be in agreement with Karfiol's conclusions and prefer one of the many other methods in common usage. For example, LEYDIG, of St. Louis, discusses the *treatment of fractures of the neck of the femur* and gives the results following the use of the Smith-Peterson nail in a group of 78 patients treated during 1937.

SURGEONS of an older generation learned from many bitter experiences with children suffering from diphtheria just how to perform a *tracheotomy*, but the introduction of antitoxin and the decrease in the number of cases of diphtheria have made the emergency operation of tracheotomy a rare one. Many of the younger generation of surgeons have probably never seen the operation, much less performed it. Mr. CAWTHORNE, of London, describes in detail just how to perform the unhurried, planned operation of tracheotomy so that the surgeon may well be acquainted with the procedure when circumstances demand a hurried operation.

THE moot question of just how much thyroid gland should be removed in a patient with hyperthyroidism is one which must be judged by every surgeon interested in *thyroid surgery*. CATTELL and PERKIN of the Lahey Clinic present evidence which suggests that the pre-operative blood iodine level may be used as an index to determine the amount of gland tissue to be removed. Thus, an attempt is made to remove the question from one of personal judgment and place it upon a more scientific factual basis.

THE popularization of the use of *continuous suction applied to the indwelling duodenal tube* by Wangensteen and his associates at the University of Minnesota has led to rather widespread discussion of how long is required for dechlorination to do harm incident to the aspiration of the gastroduodenal secretions; how much fluid and what kind of fluid should be given; and how the loss of fluid and sodium chloride can be estimated quickly and practically. PAINE from the surgical department of the University of Minnesota discusses this question and suggests two practical clinical methods for the quantitative estimation of the chlorides in the urine.

SURGEONS, gynecologists, and obstetricians are all interested in any suggestion that makes *blood transfusion* simple, efficient, and rapid. Some institutions have found the answer in the employment of a transfusion team. Others use blood banks. Professor A. HUSTIN and Dr. A. DUMONT, of Brussels, describe a method which they use in transfusing citrated blood. Perhaps the reader will like his own method much better but he may get some suggestions for improvement from Professor Hustin's article.

THERE have been many modifications of the basic operation for gastrostomy and perhaps each surgeon has evolved his own method and technique, but we believe that our readers will be interested in the well illustrated method for an *aseptic double-valved tubogastrostomy* described by GLASSMAN and based upon work done in the anatomical and surgical departments of the University of Illinois. This should be particularly interesting to the younger surgeon who may not have had a considerable experience with the operation of gastrostomy. This is also true of the beautifully illustrated article by HOAG and SAUNDERS which describes a jejunoplasty for the relief of obstruction following gastro-enterostomy or subtotal resection of the stomach. The advantages which

the authors point out in favor of the operation of jejunoplasty for this complication of what may seem to be a perfectly performed anastomosis or resection can be appreciated easily. They believe that this procedure should reverse the mortality rate following this complication because it relieves the obstruction at the actual point of occurrence with the minimum amount of surgery and, at the same time, permits direct inspection of the gastric stoma.

GYNECOLOGISTS and obstetricians may derive pleasure in entering the old controversy over whether or not a *myomectomy or* a *hysterectomy* should be done when fibroids complicate pregnancy and the fetus is viable. HUBER, formerly of Chicago, now of Indianapolis, evaluates the merits of each procedure and outlines in detail the management that he advises after consideration of all the problems concerned. Likewise, you may be interested in the fact that Professor ZONDEK, for various reasons, which he explains, is now performing myomectomy even more frequently than was his custom in the past. His experiences and indications are enumerated in a very interesting fashion.

IN the past the Editors have subscribed to the commonly held theory that all students of medicine welcome the opportunity to study the life, work, and environment of the great contributors to their profession, particularly if these are offered in an attractive and easily readable form. Our experience has confirmed that belief.

Recently we have brought reproductions of fine engravings of well known portraits of outstanding men in medicine to our readers. This effort has been based on the conception that a fine gallery of art would serve better if it were mobile; that is, if its fine works of art could be placed on exhibition at intervals in every larger city in the country. We have, as a matter of fact, tried to do more than this. Each of these reproductions can be removed from the Journal and framed or preserved in any manner our readers choose.

We intend to add to the group already published an engraving by Henry Cousins of an Andrew Morton painting of SAMUEL COOPER. The senior surgeon to the North London Hospital, Cooper was the Samuel Johnson of medical literature. Though of a different stamp, and written with a different object, his *Dictionary* was to surgery what Johnson's great work was to English literature.

Sir Thomas Lawrence was a great artist and a Turner engraving of his magnificent portrait of Sir HENRY HALFORD, we think will please you. Physician to four successive sovereigns of England—George III, George IV, William IV, and Queen Victoria—he may be the one who long ago expressed the reason for the present interest of the laity in the life of doctors, when he said: "The conduct of a physician on whom is fixed the only hope of saving life, and on whom the dying look often rests, before the eye is closed forever, may fairly be thought interesting to every hearer."

The Editors hope that you will find these subjects which are to be discussed in forthcoming issues of SURGERY, GYNECOLOGY AND OBSTETRICS interesting and that these beautiful portraits will afford you pleasure.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE authors of *Surface and Radiological Anatomy*[1] have, commendably, ventured to move beyond the customarily accepted range of treatises on surface anatomy. To the established methods of physical examination, they have added those of radiology; thus a dependable old method is modernized and vitalized by the addition of a new.

Illustrations are bountifully used; through their excellent character, the authors have succeeded in co-ordinating radiographic anatomy with those external bodily features discoverable by sight and touch, and these in turn with the details of deeper morphology with which the reader has become familiar in the dissection laboratory. Pictorially, the student and the practitioner is furnished with a superb record of human structure, accruing from three branches of anatomic science, by means of which he is enabled to view the body as if it were a transparency, transfer to its external regions the sites of osseous, visceral, vascular, and nervous elements.

Each "part" of the human body is treated on a systematic plan. To select an example, the superficial muscles of the extremities are discussed as palpable structures in relation to surface outlines, these relations being rendered graphic by the employment of parallel illustrations; their margins are described in reference to bony prominences, to fossæ produced by their elevations, and to deeper structures discoverable by palpation; the important contents of the fossæ are, in turn, described as to position and course within the space. The discussion then proceeds to movements possible at the particular joint, the movement of individual bones being illustrated by photographs of a living subject, upon which the outlines of the bones have been projected; radiographs, presented in serial order, illustrate the changing interrelationship of bones which compose the joint.

In the chapters on the thorax and the abdomen, the reader is carried successively through a discussion of surface landmarks, of parietal musculature and of contained viscera.

There is an uncommonly good discussion of the principles of radiological examination, supplemented by drawings to illustrate the special significance and anatomy of oblique views. Where radiography may profitably be supplemented by direct examination of the living organ, gastroscopy, cystoscopy, et cetera, are added to the authors' abundant list of features.

During the years in which the reviewer has employed radiography as an adjunct to the regular course in dissection, the need for such a textbook has been constantly felt. Altogether, this is a remarkable work. So inclusive is the content, so logical the arrangement of subject matter, that it may safely be recommended to the medical student, in any period of his training, and to the practitioner.

BARRY ANSON.

AN extremely well compiled review of the literature in regard to sulfanilamide therapy of bacterial infections is presented by Mellon, Gross, and Cooper.[2] The early history of the drugs is of special interest from the standpoint of a therapeutic applicability of the azo compounds.

There are chapters on the pharmacology, chemistry and chemotherapeutic effects of sulfanilamide. In these chapters, the authors have very thoroughly reviewed the literature including all of the important references in regard to the experimental uses of the drug. The chapters on the experiments *in vitro* and *in vivo* should be read by anybody who is using sulfanilamide compounds. Other high points of interest are the effects reported in infections other than the streptococcus group, namely: meningitis, gonococcus, and pneumococcus infections.

The reviewer would certainly like to commend the authors for compilation of so much valuable data concerning a drug of which so little is generally known. This book at least begins to fill a large gap in our knowledge of chemotherapy.

GILBERT H. MARQUARDT.

THE book *Practical Otology*[3] by Dr. Levine is written from thirty years' experience of teaching graduate students and is essentially a compilation of a series of lectures given during that period. It is not a textbook in the usual sense as all controversial subjects and long drawn out descriptions are left out; the author devotes himself to short, concise descriptions of the subject matter.

The book has been entirely overhauled and rewritten with new chapters on the latest work on petrositis and aviator's ear. There is a valuable formulary accompanying each chapter on treatment.

[1] SURFACE AND RADIOLOGICAL ANATOMY; FOR STUDENTS AND GENERAL PRACTITIONERS. By Arthur B. Appleton, M.A., M.D.(Cantab.), William J. Hamilton, M.D., B.Ch.(Belf.), D.Sc.(Glas.), F.R.S.E., and Ivan C. C. Tchaperoff, M.A., M.D., B.Ch.(Cantab.), D.M.R.E. Baltimore: William Wood & Co., 1938.

[2] SULFANILAMIDE THERAPY OF BACTERIAL INFECTIONS; WITH SPECIAL REFERENCE TO DISEASES CAUSED BY HEMOLYTIC STREPTOCOCCI, PNEUMOCOCCI, MENINGOCOCCI, AND GONOCOCCI. By Ralph R. Mellon, M.D., Dr. P. H., D.Sc.(Hon.), Paul Gross, M.D., and Frank B. Cooper, M.D. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1938.

[3] PRACTICAL OTOLOGY. By Morris Levine, M.D., F.I.C.S. 2d rev. ed. Philadelphia: Lea & Febiger, 1938.

The postgraduate student will find a ready and helpful guide to the problems of otology and the undergraduate and the general practitioner will find a useful consultant and aid to diagnosis and treatment of diseases of the ear.

Twenty-six chapters and over four hundred pages with fifty illustrations comprise the text.

JOHN F. DELPH.

THE *Outline of Roentgen Diagnosis*[1] represents a revision and expansion of the lecture notes used by the author in the teaching of roentgenology. As the title indicates and as the author states in the preface, this book is not a reference work but rather a synopsis of a very extensive subject. It goes without saying that it would be impossible to discuss and illustrate in detail the many uncommon conditions or to elaborate upon the rarer manifestations of the common diseases in a text of this type. The subject matter is dealt with in an orderly and concise manner and is a tribute to the author's experience in teaching. The indications, possibilities, and limitations of a roentgen study in each disease process are stressed throughout the text.

The book has been made up in two formats. One includes a pictorial atlas of 254 illustrations and reproductions of roentgenograms while in the other, suitable for teaching, the atlas section has been omitted. Although the atlas appears at the end of the volume, there are numerous references and cross references in the text to this section. The reproductions of roentgenograms are excellent and wisely chosen. Line drawings are utilized rather extensively and in most instances illustrate the lesion very well, but in others it would seem that reproductions might have been used to better advantage. This is not, however, a major fault. In illustrating many lesions the author has very wisely used line drawings rather than roentgenograms which often fail to reproduce well enough to demonstrate clearly the lesion under consideration. The unique drawings by Jean E. Hirsch illustrating the diseases of bones and joints are worthy of note. All illustrations are reproduced in the negative.

The subject matter has been divided into the following sections: general principles of roentgen diagnosis, bones and joints, diseases of the spine and spinal cord, skull and its contents, thorax, digestive tract, gall bladder, abdomen, urinary tract, female generative organs, and miscellaneous. All of the common disease processes falling under these various headings are adequately discussed.

This volume should be of interest to teachers of roentgenology. The author's orderly and concise manner of presenting the whole subject makes the book ideal for class room work and as a text for graduate students. It is recommended to members of the medical profession as a valuable addition to their library.

EARL E. BARTH.

[1] OUTLINE OF ROENTGEN DIAGNOSIS: AN ORIENTATION IN THE BASIC PRINCIPLES OF DIAGNOSIS BY THE ROENTGEN METHOD. By Leo G. Rigler, B.S., M.B., M.D. Atlas and student editions. Philadelphia, London, Montreal, and New York: J. B. Lippincott Co., 1938.

THE third edition of *A Textbook of Gynecology*[2] by Arthur Hale Curtis, contains eight new chapters on anatomy, physiology, and the endocrine glands, which were not discussed formally in the two previous editions. The subject matter has been entirely rewritten and is based on the author's own experience combined with carefully selected excerpts from the current literature.

The chapter on anatomy is exceedingly timely because it is presented from the gynecologic standpoint and represents new and original work in dissection of the cadaver as well as in the operating room, coupled with Dr. Curtis' wide experience in this field. The drawings are unique in that they are original and made from dissections.

The discussion of organotherapy is excellent. The author's statement that "the average clinician is endocrine conscious and has endocrine panic," is very apt. Without camouflage, he presents the various gynecological disorders, which, in the past few years, have been treated with good, bad, and indifferent results; and he indicates clearly the few ailments successfully handled at the present time with the various preparations now available.

Descriptions of the more common gynecological operative procedures are included and they are clear, thorough and well chosen, as well as, accompanied by unusually fine illustrations. The importance of preoperative and postoperative care is stressed and the management of various complications included. The indications and contra-indications for radiotherapy are ably discussed and the use of sulfanilamide in various pelvic disorders is described.

This is a book of 603 pages and 318 illustrations; it covers in a concise, direct manner the whole field of gynecology, and for this reason is ideal for the student and general practitioner; it also is a valuable addition to the gynecologist's library.

JAMES C. MASSON.

THE English translation of *The Vitamins and Their Clinical Application*,[3] published in Germany the early part of 1936, was made in the early part of 1938. The manual is an informative résumé of the history of vitamins and the progress made in vitamin science during the few years previous to 1936.

A historical introduction is presented on each of the known vitamins. There then follows discussions on the chemistry (giving chemical formulas), determination, occurrence, manifestation of the vitamin deficiency, and the daily requirements in man. Attention is called to some of the reliable commercial preparations, with dosage, that may be used in treating vitamin deficiencies. The last three chapters are discussions on: vitamins and human nutrition, daily vitamin requirements for man, and the antagonism of vitamins and its importance in vitamin therapy.

[2] A TEXTBOOK OF GYNECOLOGY. By Arthur Hale Curtis, M.D. 3d ed. Philadelphia and London: W. B. Saunders Co., 1938.

[3] THE VITAMINS AND THEIR CLINICAL APPLICATION. By Prof. Dr. W. Stepp, Doz. Dr. Kuehnau, and Dr. H. Schroeder. Translated by Herman A. H. Bouman, M.D. Milwaukee, Wis.: The Vitamin Products Co., 1938.

This manual offers a clear presentation of the subject of vitamins and their practical application to the human being both in health and disease. However, the reader must bear in mind the many new discoveries that have been made in vitamin science during the past 3 years. The vitamin chart with detailed bibliography (found in the appendix) offered by the English editors is valuable for those who desire to make a special study of the vitamins. References on this chart are only up to 1937. C. J. BARBORKA.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

CLINICAL ELECTROSURGERY. By Gustavus M. Blech, G.C.S., G.C.G., M.D., LL.D. With chapters by Hector Alfred Colwell, M.B., Ph.D., D.P.H., L.R.C.P., M.R.C.S., and Brian Wellington Windeyer, F.R.C.S., D.M.R.E. London, New York, Toronto: Oxford University Press, 1938.

ORTHOPEDIC APPLIANCES; THE PRINCIPLES AND PRACTICE OF BRACE CONSTRUCTION FOR THE USE OF ORTHOPEDIC SURGEONS AND BRACEMAKERS. By Henry H. Jordan, M.D. Foreword by E. G. Brackett, M.D. New York, London, Toronto: Oxford University Press, 1939.

THE OBLIQUELY CONTRACTED PELVIS; CONTAINING ALSO AN APPENDIX OF THE MOST IMPORTANT DEFECTS OF THE FEMALE PELVIS. By Dr. Franz Carl Naegele. Mainz: Victor von Zabern, 1839. Centennial Edition, Newly Translated from the Original German by Alfred M. Hellman, M.D., F.A.C.S., and George Musa, M.D. New York, 1939.

ANATOMIE CHIRURGICALE DU CRÂNE ET DE L'ENCÉPHALE. Published under the direction of André Latarjet. By Charles Clavel and Michel Latarjet. Paris: G. Doin & Cie, 1938.

ANATOMIE ET HISTOLOGIE DE L'APPAREIL URINAIRE ET DE L'APPAREIL GÉNITAL DE L'HOMME. By A. Hovelacque and Jean Turchini. Paris: G. Doin & Cie, 1938.

SURGICAL TECHNIQUE AND PRINCIPLES OF OPERATIVE SURGERY. By A. V. Partipilo, M.D., F.A.C.S. 3d ed. Chicago: Chicago Post-Graduate School of Surgery, 1938.

THE ABNORMAL IN OBSTETRICS. By Sir Comyns Berkeley, M.A., M.C., M.D. (Cantab), F.R.C.P. (Lond.), F.R.C.S. (Eng.), M.M.S.A. (Hon.), F.C.O.G., Victor Bonney, M.S., M.D., B.Sc. (Lond.), F.R.C.S. (Eng.), F.R.A.C.S. (Hon.), M.R.C.P. (Lond.), and Douglas MacLeod, M.S., M.B (Lond.), F.R.C.S. (Eng.), F.R.C.P. (Lond.), M.C.O.G. Baltimore: William Wood & Co., 1938.

CONSULTATION ROOM. By Frederic Loomis, M.D. New York: Alfred A. Knopf, 1939.

TRANSACTIONS OF THE FIFTY-NINTH MEETING OF THE AMERICAN SURGICAL ASSOCIATION. Vol. 56. Edited by Walter Estell Lee, M.D. Philadelphia: J. B. Lippincott Co., 1938.

THE TREATMENT OF FRACTURES. By Charles Locke Scudder, A.B., Ph.B., M.D., F.A.C.S. 11th rev. ed. Philadelphia and London: W. B. Saunders Co., 1938.

TEXTBOOK OF NEURO-ANATOMY AND THE SENSE ORGANS. By O. Larsell, Ph.D. New York and London: D. Appleton-Century Co., Inc., 1939.

TRAUMA AND INTERNAL DISEASE; A BASIS FOR MEDICAL AND LEGAL EVALUATION OF THE ETIOLOGY, PATHOLOGY, CLINICAL PROCESSES, FOLLOWING INJURY. By Frank W. Spicer, A.B., M.D., F.A.C.P. Philadelphia, London, Montreal: J. B. Lippincott Co., 1939.

SURGERY OF THE EAR. Edited by Samuel J. Kopetzky, M.D., F.A.C.S. New York and Edinburgh: Thomas Nelson & Sons, 1938.

AMERICAN COLLEGE OF SURGEONS

PROCEEDINGS OF TWENTY-EIGHTH ANNUAL CLINICAL CONGRESS

NEW YORK - BROOKLYN

OCTOBER 17-21, 1938

AMERICAN COLLEGE OF SURGEONS

OFFICERS

HOWARD C. NAFFZIGER, San Francisco, *President*
VERNON C. DAVID, Chicago, *First Vice President*
FRASER B. GURD, Montreal, *Second Vice President*
DALLAS B. PHEMISTER, Chicago, *Treasurer*
FREDERIC A. BESLEY, Waukegan, *Secretary*

BOWMAN C. CROWELL and MALCOLM T. MACEACHERN, *Associate Directors*
HAROLD EARNHEART, M. N. NEWQUIST and E. W. WILLIAMSON, *Assistant Directors*
A. D. BALLOU, *General Manager, Clinical Congress*

OFFICERS-ELECT

GEORGE P. MULLER, Philadelphia, *President*
HENRY W. CAVE, New York, *First Vice President*
D. EDWIN ROBERTSON, Toronto, *Second Vice President*

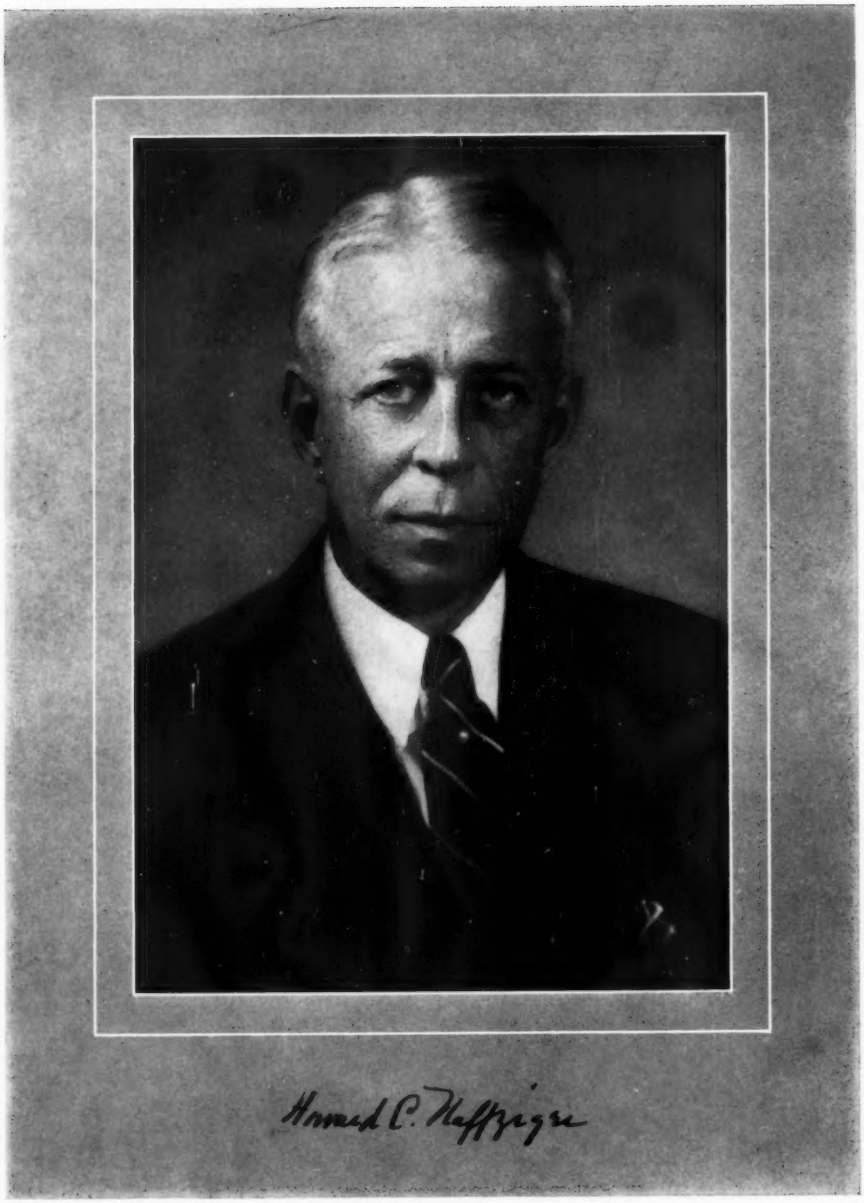
BOARD OF REGENTS

GEORGE CRILE, Cleveland, *Chairman*
IRVIN ABELL, Louisville, *Vice Chairman*

G. A. B. ADDY, Rothesay
ARTHUR W. ALLEN, Boston
DONALD C. BALFOUR, Rochester
FREDERICK A. COLLER, Ann Arbor
WILLIAM DARRACH, New York
JOHN R. FRASER, Montreal
HARRY S. GRADLE, Chicago
JOHN E. JENNINGS, Brooklyn
JAMES MONROE MASON, Birmingham
GEORGE P. MULLER, Philadelphia
ALEXANDER R. MUNROE, Edmonton
HOWARD C. NAFFZIGER, San Francisco
ALTON OCHSNER, New Orleans
ARTHUR M. SHIPLEY, Baltimore

ADVISORY COUNCIL

JOHN M. T. FINNEY, Baltimore
CHARLES H. MAYO, Rochester
WILLIAM J. MAYO, Rochester



PRESIDENT 1938-1939

UNIV. OF MICH.

SURGERY
GYNECOLOGY AND OBSTETRICS
An International Magazine, Published Monthly

VOLUME 68 FEBRUARY 15, 1939 NUMBER 2A

HERNIATION THROUGH THE DIAPHRAGM

JOHN J. MORTON, M.D., F.A.C.S., Rochester, New York

HERNIATION through the diaphragm occurs more frequently than is generally recognized by physicians. If the practitioner will suspect it as a cause for unexplained epigastric or lower thoracic complaints, and if he will follow up by the proper examinations, he will be gratified by the number of diagnoses to his credit.

In its development from the septum transversum and its accession of sternal, costal, and lumbar musculature, the diaphragm offers many opportunities for imperfect fusion of these elements. Thus, there may be abnormal openings through it from a failure in appearance, in timing, or in the fusion of the separate components. This is likely to take place peripherally in the posterolateral areas between the costal and lumbar regions, leaving the Bochdalek's foramina; or in the parasternal region, the so called foramina of Morgagni (the *fente de Larrey* of the French writers). Added to this is the fact that the stomach also forms in the thoracic region and has to descend, rotate, and assume its adult position, all in proper timing relationship to the formation of the diaphragm. In consequence, there may be complete failure of the stomach to get below the diaphragm (the thoracic stomach), or partial descent with varying degrees of thoracic and abdominal gastric portions; or small remnants of the cardiac end of the stomach may be nipped off near the esophageal hiatus; or there may be simply an imperfectly formed area near the esophagus, a potentially weak spot which may determine the site of a future herniation if given the proper conditions.

From the Department of Surgery, the University of Rochester School of Medicine and Dentistry.

Presented before the Clinical Congress of the American College of Surgeons, New York, 17–21, 1938.

TYPES OF HERNIAS

In the literature, herniations through the diaphragm are classified as true or false, depending on the presence or absence of a hernial sac. They are also considered to be congenital, traumatic, or acquired. Any of these latter groups may or may not have a true sac present. The classification is mainly one of convenience. It would be equally proper to consider some of these protrusions through the diaphragm as due to faulty fusion of the muscles, absence of portions of the diaphragm, imperfect descent of the stomach: or in case of trauma, internal eviscerations through the diaphragm.

1. *Congenital.* In the etiology of the congenital hernias, the trouble usually can be traced to the imperfect development of some portions of the diaphragm, or to the improper descent of the stomach and esophagus through the diaphragm. The congenital herniations may give symptoms immediately after birth. In such a case, there is cyanosis, dyspnea, and embarrassment of the circulation. Certain positions make the condition worse while

others relieve it. There may be alarming and critical attacks alleviated only by administration of oxygen. These patients may require surgery although the risk is very great.

CASE 1. D. C., No. 96668, a female, was admitted to Strong Memorial Hospital, December 1, 1934, at 5:30 p.m. At 6:00 a.m., December 2, she gave birth to a male infant after a normal delivery. The child was very cyanotic at birth but was resuscitated. Three attacks of extreme cyanosis and dyspnea occurred during the day. Breath sounds were very faint over the left chest where there was slight fullness, anteriorly and laterally; there was cardiac dullness anteriorly on the right; the point of maximum impulse was in the fourth right interspace. The roentgenogram showed herniation through the diaphragm. When on the left side, cyanosis was less, but several attacks necessitated the use of the oxygen tent. An exploration was performed on December 6, but it was impossible to return the organs from the chest by either the thoracic or the abdominal route. An oxygen tent was employed after operation, but the infant died on December 8, 1934.

Some infants do not survive the first day.

CASE 2. B. B., No. 88262, a boy baby who died soon after birth. At postmortem examination a large opening was found posteriorly through the left diaphragm. The stomach, the small intestine, and all of the large intestine down to the descending colon occupied the left thoracic cage. The mediastinum was shifted to the right. There was co-arctation of the aorta and dilatation of the ductus arteriosus.

Other patients may adjust themselves to the changed relationships and be considered normal. Only later in life it may be noted that they are below the average development for their age and that an abnormality in the shape of the thorax exists. Such patients may present no symptoms referable to their herniation.

CASE 3. H. S., No. 80308, a boy, aged 12 years, in good health till September 14, 1933, was admitted to Strong Memorial Hospital on September 21, 1933, because of a respiratory infection followed by diabetes mellitus. Previous history revealed pneumonia at 2 years. Examination showed prominence of the anterior chest wall, region xiphoid; dullness on percussion on left side from angle scapula to base, forward to anterior axillary line; signs of fluid; diminished breath sounds and vocal fremitus. Diagnosis showed resolving pneumonia, thickened pleura, and pleural effusion. Roentgenographic diagnosis revealed consolidation or pleural effusion. Gurgling sounds heard suggested bowel investigation. A gastro-intestinal series showed herniation of the large and small bowel through the diaphragm (Fig. 1).

There may be very trivial upsets in digestion.

CASE 4. R. F., No. 70751, a boy, aged 5 years, was admitted to Strong Memorial Hospital, January 20, 1933. There had been irregular vomiting for 2 years usually at night but no other complaint. Temperature was normal; pulse 100; respirations 20; white blood cells 6,000. The left thorax was more prominent than the right; in the left lung from mid scapula to base, vocal fremitus was decreased and percussion note flat, but there were no râles. Heart sounds were heard best to the right; no shift of heart was made out. There were prominent veins over the upper abdomen, and numerous walnut-sized masses on both sides of the abdomen. Various diagnoses of pleural effusion, unresolved pneumonia, tuberculosis, lung abscess and bronchiectasis were considered by attending physicians (Fig. 2). Signs and symptoms did not fit any of these diagnoses. The possibility of herniation was finally suggested, and a gastro-intestinal series made the diagnosis sure. Operation was performed and the organs were restored to the abdominal cavity. The posterior defect in the diaphragm is demonstrated in Figure 3. The wound was packed to form adhesions and the result was good.

Some patients may go through life with very few complaints (Cases 5 and 6).

CASE 5. C. F., No. 106886, a man, aged 61 years, was admitted to Rochester Municipal Hospital on September 14, 1935, with a fractured left hip. Examination showed the patient to be semicomatose; the entire chest full of râles; complete fracture of the left femoral neck, arteriosclerosis, and auricular fibrillation. He died in 24 hours. Postmortem examination revealed bronchopneumonia, pulmonary fat embolism, cirrhosis of the liver, and other signs of degeneration due to age. In addition, the right diaphragm showed a bulging into the right cavity behind a band of fibrous tissue which extended from the spine to the anterolateral chest wall. This diaphragmatic herniation contained the right lobe of the liver and lateral to it some small bowel loops.

CASE 6. A.H., No. 40178, a male, aged 70 years, was admitted to Strong Memorial Hospital on October 19, 1930. He had intermittent pain in the epigastrium for 1 year, a loss in weight of 30 pounds, icterus, emaciation, hypertension, bladder retention, benign prostatic hypertrophy, cystitis, fever; white blood cells, 18,000 to 32,000; and anemia. A gastro-intestinal series showed a mass in the pyloric region, and herniation of the transverse colon through the diaphragm (Fig. 4). Under scopolamine and local anesthesia, the abdomen was explored. Chronic cholelithiasis, cirrhosis, and chronic pancreatitis were found and a cholecystduodenostomy was performed. The patient died 14

days later of bronchopneumonia, myocarditis, prostatic hypertrophy, hydro-ureter and hydronephrosis.

Congenital herniations through the parasternal area may give precordial pain, a feeling of tightness in the chest, retrosternal pressure, or palpitation. Strangulation of the bowel with its accompanying symptoms has occurred in 10 per cent of the reported cases of retrosternal diaphragmatic hernia (12).

CASE 7. E. M., No. 47362, a male, aged 22 years, was admitted to Strong Memorial Hospital on May 10, 1931. As long as he could remember he had had a constant, dull pain in the left chest medial to nipple and low; this grew worse with exercise and on deep inspiration. He traced his trouble to an injury received 8 years previously. He had fallen downstairs with a bicycle, the pedal puncturing the left abdominal wall, but the peritoneum was not opened. Examination showed the left side of lower chest to be slightly more prominent than the right, and a circular scar on the left epigastrium. Otherwise he was normal. The roentgenogram showed the transverse colon through the diaphragm (Figs. 5 and 6). Operation was performed with a left phrenic block. There was a well-formed sac with the transverse colon adherent, which was dissected free and the diaphragm closed. The patient is now well.

The diagnosis of congenital herniation through the diaphragm is exceedingly difficult to make at times. The symptoms caused by these hernias have been detailed in the preceding paragraphs. The signs given by herniated viscera into the thoracic cavity are variable and difficult to evaluate. The combinations of air, fluid and solid material produce many peculiar signs. The congenital and traumatic types are likely to confuse the physician, as there are usually more contents in the thoracic cage in these varieties.

In the last analysis, the diagnosis is possible only by accurate roentgenograms which show the position of the organs in relation to the diaphragm. It may be necessary to give barium by mouth to outline the organs involved accurately. When the large bowel is in the herniation, a barium enema will demonstrate the portion of the colon which is participating.

The prognosis depends upon the size of the opening through the diaphragm and the character of the herniated viscera. When the vital capacity is much reduced, the infant may not survive the early days. As he becomes more

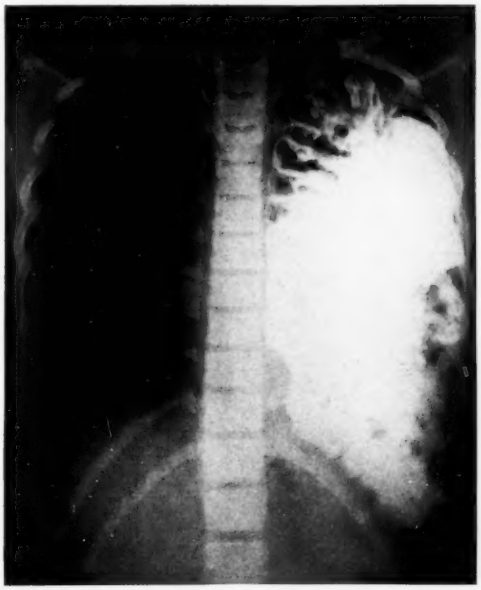


Fig. 1. Case 3. This is the usual picture of a herniation of the small and large intestine through the left posterolateral Bochdalek's foramen.

accommodated to the compression of the lungs he may compensate for it by expansion of the opposite side. The pressure on the mediastinum may cause a considerable shift of its contents. In theory it is possible that the heart and great vessels may be embarrassed by the abnormal mechanical pressure. When once the infant passes the early critical period, he may not show any evidence of trouble except perhaps in general underdevelopment and in distortion of the thoracic cage. These have been noted frequently by keen clinical observers. There is always the danger of potential obstruction and strangulation, although in my experience this is far less frequent than has been reported by others. Strangulations in herniations through the foramen of Morgagni have been reported in 10 per cent of cases (12).

The treatment depends upon the type of the lesion and the nature of the symptoms it produces. The congenital types should probably be operated upon at a favorable time when possible, and under stress conditions when necessary. The most common postero-

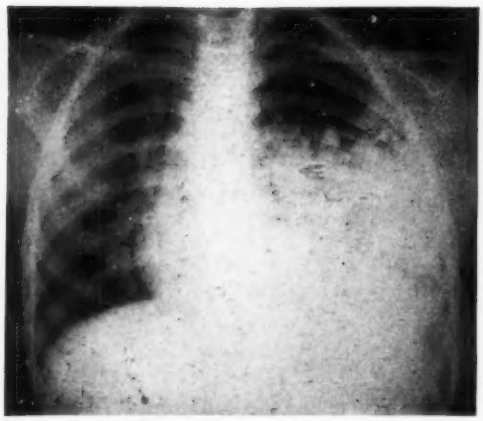


Fig. 2. Case 4. A roentgenogram such as this is quite confusing for interpretation.

Fig. 4. Case 6. Bilateral herniation through the parasternal foramina (Morgagni).

lateral variety through the foramen of Bochdalek can be approached either by the thoracic or abdominal route or a combination of the two. A lateral thoracic incision between the ninth and tenth ribs will usually expose the defect and allow easy closure by removal of an overlying rib, if necessary, for relaxation. This is not so easily done from the abdominal side. The parasternal types should have a preliminary phrenic block and closure from the abdominal route. In those unusual congenital herniations through the central tendinous area or in the para-esophageal region, the operations to be described for the traumatic and acquired types should be successful.

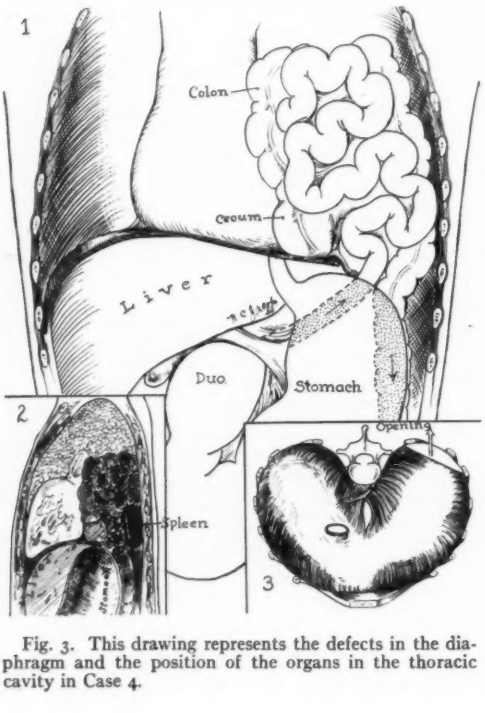


Fig. 3. This drawing represents the defects in the diaphragm and the position of the organs in the thoracic cavity in Case 4.

2. Traumatic. Traumatic herniations through the diaphragm are the results of tears through the muscular or tendinous portions with the escape of abdominal viscera into the thorax, aided and abetted by the differences of pressure between these two cavities. The trauma necessary to cause a tear in the diaphragm almost always represents a severe injury of some kind to the lower thorax or upper abdomen. Such injuries occur from anything which causes violent doubling or torsion of the body such as auto accidents, falls, machinery accidents, gunshot wounds, stab wounds, or heavy lifting. Traumatic herniation has occurred at childbirth, or from the rupture of an abscess through the diaphragm from either side—a subphrenic abscess or empyema.

Often times the symptoms of traumatic herniations are masked by the shock incident to the severe accompanying trauma. In some instances, however, the condition makes itself

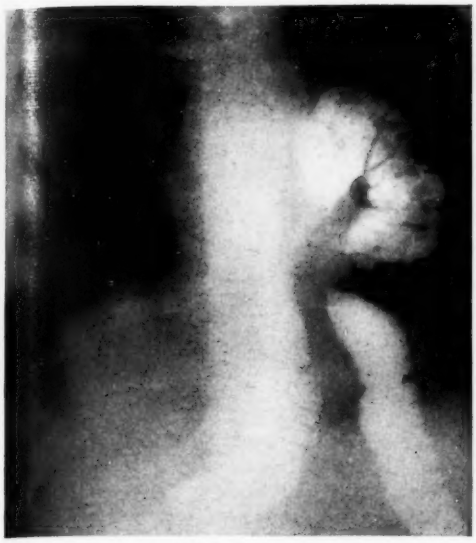


Fig. 5. Case 7. Herniation of transverse colon through left parasternal defect (Morgagni's foramen).

Fig. 6. Case 7. Lateral view indicating the constriction of the bowel at the sac opening.

known by acute dilatation of the abnormally situated organs. If not relieved relatively soon, it may lead to strangulation.

Case 8. R. C., No. 114648, a male, aged 32 years, was admitted to the Strong Memorial Hospital on May 4, 1936. In an auto accident 3 days previously he suffered a fracture of the left ilium, right clavicle, and herniation of the stomach through the left diaphragm. The left chest lagged on inspiration. Percussion note was tympanitic anteriorly from the third left interspace to the ninth left interspace; there were also splashing and gurgling sounds. There were no breath sounds; vocal fremitus was decreased; there was an absence of tactile fremitus, and the heart was displaced to the right. The electrocardiogram showed auriculoventricular heart block and myocardial damage; Wassermann reaction was 4 plus. Operation was performed with a phrenic nerve block and the rent in the diaphragm was repaired. The tear was to the right of the esophageal hiatus. The cardia and the pylorus were side by side at the level of the diaphragm. Omentum and splenic flexure were drawn up into the chest. It was necessary to enlarge the rent to free the organs. The stomach was markedly dilated. Exposure was obtained by a costoplastic procedure. A stormy convalescence followed, but the patient was discharged in good condition on August 19, 1936 (Fig. 7).

In other accidents the herniation symptoms are completely submerged. It may be months or years before the condition is suspected or makes itself known. There may then follow symptoms referable to the occlusion of the viscera which have herniated through the tear in the diaphragm. There will also be a gradual compression of the lung on the involved side with a diminution in the vital capacity. In Case 9 this amounted to 28 per cent. The heart is slowly displaced toward the opposite side of the chest by pressure on the mediastinum. This may lead to cardiac disturbance by angulation and distortion of its vascular connections.

Case 9. F. M., No. 113380, a woman, aged 33 years, was admitted to Strong Memorial Hospital on May 18, 1936. She was in an auto accident August 29, 1935, and suffered a fracture of 6 ribs on the left side. She remained in the hospital 1 month and another month with relatives. On her return home, she suffered pain in the back, shortness of breath, and sharp pain while eating. A roentgenogram revealed herniation of the stomach, transverse colon, splenic flexure into the chest, and a heart displaced to the right. Examination showed angulation of the second to the eighth ribs on the left, posteriorly; percussion note was dull with moderate tympany over the left thorax, laterally and posteriorly, and

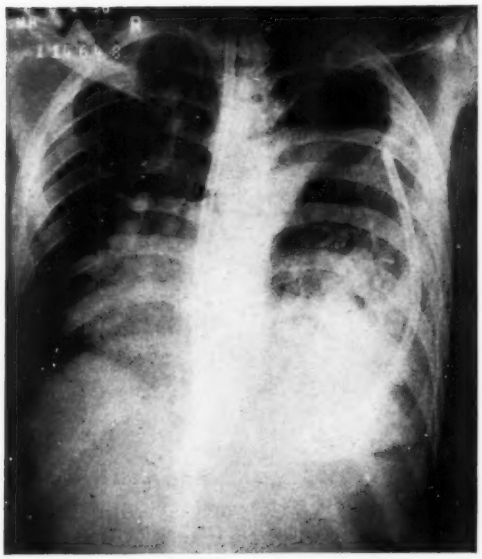


Fig. 7. Case 8. Traumatic rupture of the left dome of the diaphragm. The stomach has herniated into the left thoracic cavity. It is obstructed and operation is imperative. Catheter shows in much dilated stomach.

Fig. 8. Case 9. Traumatic rupture of the left diaphragm. Gastro-intestinal series shows herniation of stomach into left thoracic cavity.

breath sounds were distant. An operation was performed by means of a phrenic block. The stomach and colon were restored to the peritoneal cavity and the torn diaphragm was repaired. Convalescence was uneventful. There has been no trouble since operation. Vital capacity before operation was 2.6 liters; after operation, 3.75 liters. Total capacity before operation was 3.50 liters; after operation, 5.25 liters. The vital capacity was reduced 28 per cent. Carbon dioxide and oxygen of the arterial blood before operation were normal. The dyspnea was due to reduced vital capacity and pulmonary reserve (Figs. 8, 9, 10).

Herniations of the traumatic type can be handled from the thoracic or from the abdominal approach. Surgeons who do a great deal of thoracic surgery usually prefer the thoracic operation. The claim is made that it is easier to work from the upper side of a tear with everything below you than it is to work on the under side with everything above. Others choose the abdominal operation as it is easier in their hands. There should be no quarrel regarding the relative merits of these methods. The well equipped surgeon should be prepared to operate by either or both approaches if necessary. The tear in the central tendon should be freshened and approximated accurately. Temporary paralysis of the diaphragm by phrenic nerve crush may be of assistance although it is not always a necessity. If the approach is through the thorax, this can be carried out or not as needed.

3. *Acquired.* Hernias of the acquired type more nearly correspond to hernias of other portions of the abdominal cavity. These acquired diaphragmatic hernias develop at areas of weakness. They often require years in their formation. An unusual strain may quickly accentuate them. They are fostered by upward pressure of the intra-abdominal viscera, by aspiration and the vacuum suction power of the thoracic cavity, by a traction cone caused by esophageal muscular contraction, and by the insinuation of fat tabs which act as entering wedges to dilate the small openings. Their para-esophageal situation is quite characteristic.

The symptoms of the acquired esophageal hiatus are the most interesting. These herniations give symptoms which may closely mimic those of gastro-intestinal conditions

Fig. 9. Case 9. The large intestine has also herniated into the thorax.

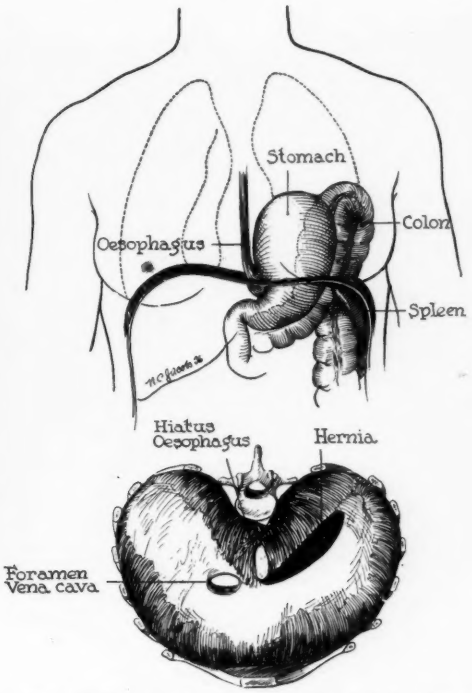


Fig. 10. Drawing showing the traumatic defect in the diaphragm and the condition found at operation in Case 9.

such as gastritis, gastric ulcer, gastric cancer, pylorospasm, duodenal ulcer, cholecystitis, and cholelithiasis; or the symptoms may be difficult to differentiate from esophageal conditions such as cardiospasm, diverticulum, benign stricture, or carcinoma of the esophagus; or finally, there is a chance to confuse these symptoms with those of some cardiac conditions such as angina pectoris, coronary occlusion, and myocardial damage. The gastro-intestinal symptoms include epigastric pain, and distress or fullness, which may or may not be relieved by soda, food, rest, belching, vomiting, or change of position. Some patients complain of this pain especially after large meals, or shortly after retiring at night. Sometimes the pain is accentuated by deep breathing or by leaning over; and often it is relieved by assuming the erect posture. The pain frequently radiates to the angle of the scapula. Belching and gas on the stomach, nausea and vomiting are relatively common. The presence of blood in the vomitus or stool, accompanied by dizziness, weakness, and severe anemia, often lead to suspicion of a bleeding ulcer. These patients occasionally have upsets in their bowel habits, diarrhea or constipation. They often develop fear of eating and in consequence may lose weight. This causes the physician to consider a diagnosis of cancer. The esophageal symptoms include the following: difficulty in swallowing, increasing inability to retain food, regurgitation, a feeling of pressure in the retrosternal region, and loss of weight and strength. The cardio-respiratory symptoms are heart pain and palpitation, substernal pain and pressure, radiation of pain to the arms, shortness of breath, and fear of impending death. Diaphragmatic spasm sometimes causes phrenic pain and hiccoughs.

As more of the stomach becomes involved in the herniation, the symptoms may intensify, become more frequent and are not relieved easily. When incarceration and fixation occur, the symptoms may become continuous de-

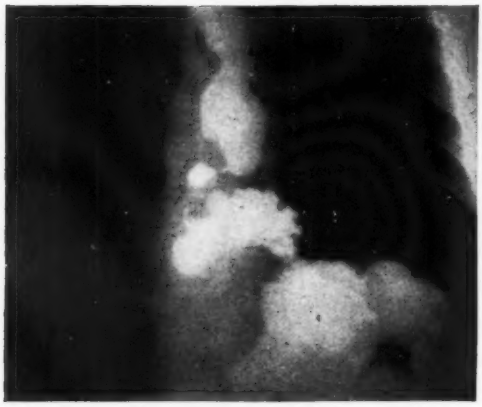


Fig. 11. Case 13. Herniation of a portion of the fundus through the para-esophageal hiatus. There is associated esophagospasm as shown by the string-like lower esophagus. This area relaxed at times and filled normally.

manding surgical intervention for relief. The bleeding is a sign of significance, indicating congestion or thrombosis of vessels about the constricting ring of the opening, with erosion of the mucous membrane and even ulceration in a number of cases.

Many patients go through their lives with only minor trouble, easily controlled by medical treatment. But when the symptoms become continuous and intense, surgery must be seriously considered.

The following case histories illustrate the variation in the symptomatology in esophageal hiatus herniations. Cases 10 and 11 demonstrate the gastro-intestinal symptomatology.

Case 10. C. C., No. 105474, a woman, aged 47 years, was admitted for the fourth time to Strong Memorial Hospital on June 21, 1937. Previous admissions were for acute gastro-enteritis, suspected gastro-intestinal malignancy, secondary anemia, and achlorhydria. Hernia through the diaphragm at the esophageal hiatus finally was demonstrated. In 1926, a laparotomy was performed because a diseased gall bladder was suspected. This was not found, and it was thought that a duodenal ulcer was present. Posterior gastro-enterostomy was done at that time. Epigastric hunger pain, 3 hours after eating, is now relieved by food and soda. Lower thoracic pain is relieved by recumbency. She obtained relief under medical treatment. She gave this up and during 5 months all symptoms grew worse with dyspnea, hypochromic anemia, and achlorhydria and she became sallow. The patient improved under medical treatment.

Fig. 12. Case 14. A large amount of the fundus has herniated through the diaphragm at the para-esophageal hiatus. The rugæ can be seen traversing the constricting edge of the sac.

Case 11. L. F., No. 122726, a male, aged 72 years, was admitted to Rochester Municipal Hospital on December 21, 1936. Nine months previously he suddenly lost his appetite because eating caused substernal pain, which radiated to both lower quadrants. There were associated nausea and vomiting. Roentgenograms at that time were reported as cancer of the lower esophagus or cardiac end of the stomach. There was a loss of 10 pounds in weight and anemia. Examination showed the patient to be emaciated, pallid, with an enlarged prostate, and secondary anemia. The gastro-intestinal series revealed diaphragmatic hernia with cardiospasm, doubtful lesion at the cardiac end of the stomach. There was achlorhydria, but there was no blood in the gastric secretion. The general opinion of consultants was against carcinoma. The patient was discharged for medical care.

Case 12 illustrates the difficulty in differentiating one of these hernias from a cardiac condition.

Case 12. No. 119025, a male, aged 48 years, was admitted to Strong Memorial Hospital on September 8, 1936. He had had a pressure sensation in the chest for 5 years, which he thought to be dyspepsia. For 1 year he suffered with palpitation and dyspnea, which he relieved by cutting down on cigarettes, 30 a day. Three weeks previous to admission he experienced a severe sensation of pressure in the chest with sharp pains in both arms. He felt as if chest and arms were gripped in a vise and this lasted 6 minutes. He suffered a similar attack the same evening. In Boston, the electrocardiogram was interpreted as coronary disease. The patient was put on heart drugs. Examination showed a heart slightly enlarged with some extra systoles; the electrocardiogram showed extra ventricular systoles and a sino-auricular block. The gastro-intestinal series revealed that the fundus slid laterally and

Fig. 13. Case 15. Large herniation with marked symptoms. Fluid retention and fluid level well demonstrated. Diaphragm shadows show through breast shadows.

anteriorly through a defect in the diaphragm on deep inspiration. The patient was discharged to his physician. Repeated attacks of discomfort after meals were found to be associated more with the hernia. He can now take strenuous exercise with a regular heart. The patient is quiescent under medical treatment but if trouble recurs surgery is to be performed.

Cases 10, 11, and 12 showed large herniations of the cardiac end of the stomach through the esophageal hiatus, similar to that in Figure 20. In Case 13 the esophageal symptoms were in the foreground.

CASE 13. E.B., No. 115330, a woman, aged 74 years, was admitted to Strong Memorial Hospital on May 22, 1936. For 2 to 3 years food had stuck in her throat and would not go down, especially solid food and cold drinks. She could swallow hot drinks. Her distress increased; food went to a point in the center of breast bone, stopped and hurt quite badly. She suffered shortness of breath, belched and regurgitated. She could usually raise a mouthful of slime in the morning. For many years the patient suffered with gas on stomach and belching but no pain and no heart burn. She was afraid to eat and had lost 10 to 15 pounds in 5 months. Examination showed her to be alert, well nourished, and normal for her age. The impression was cardiospasm, but the gastro-intestinal series revealed herniation, a part of the stomach was through the diaphragm and there was an angulation of the esophagus. Symptoms continued but the patient wanted nothing done. Phrenic nerve crush has been advised (Fig. 11).

The 3 following cases are examples of incarceration and fixation in the hernial sac. Surgery is advisable in these cases to get relief. The patients are so uncomfortable that they accept operation readily.

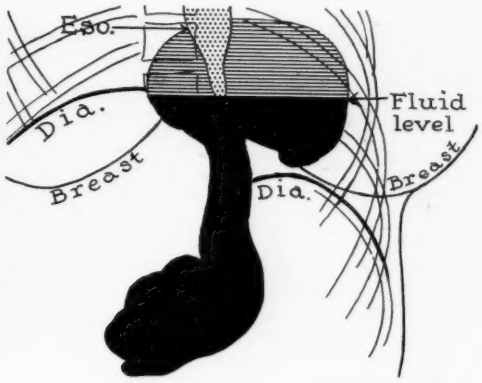


Fig. 14. Case 16. Tracing of roentgenogram showing large portion of stomach herniated through para-esophageal opening. Esophagus demonstrated to be of normal length. Operation possible.

CASE 14. E.B., No. 58045, a woman, aged 39 years, was admitted to Strong Memorial Hospital on July 6, 1932. She began to have attacks of sharp pain in the lower left chest 12 years previously but the cause was undetermined. The patient showed signs of hematemesis 4 years before. Gastric ulcer was diagnosed and strict diet gave no relief. The pains grew worse and during the last 5 weeks she had endured frequent and severe epigastric pain. For 1 week there had been constant pain, slight fever, hiccoughs and very troublesome pain radiating down the inner side of the left arm. Dyspnea had been present on exertion for 8 years. Examination showed the patient to be well developed and nourished; the general physical examination was normal. The gastro-intestinal series revealed a large herniation of the stomach through the diaphragm. She was operated upon and the herniation admitted 3 fingers easily. The spleen, adherent to the sac, was torn in freeing it. Severe bleeding followed which was controlled by suturing the spleen. The herniation was packed after partial closure. There was some shock and a slow recovery. Since operation the patient has gained 20 pounds in weight, and there is only an occasional mild discomfort in the left, upper quadrant. She has developed arthritis of moderate severity (Fig. 12).

CASE 15. M.E., No. 74049, a female, aged 53 years, was admitted to Strong Memorial Hospital on April 13, 1933. One and one half years previous to admission she began to have epigastric pain, burning in character, radiating to left upper quadrant 1 to 2 hours after eating. It was relieved by soda and vomiting. She experienced freedom from pain for 1 to 2 week periods. Two weeks before admission, respiratory infection associated with epigastric pain, nausea and vomiting were present. Examination revealed an enlarged heart and hyper-

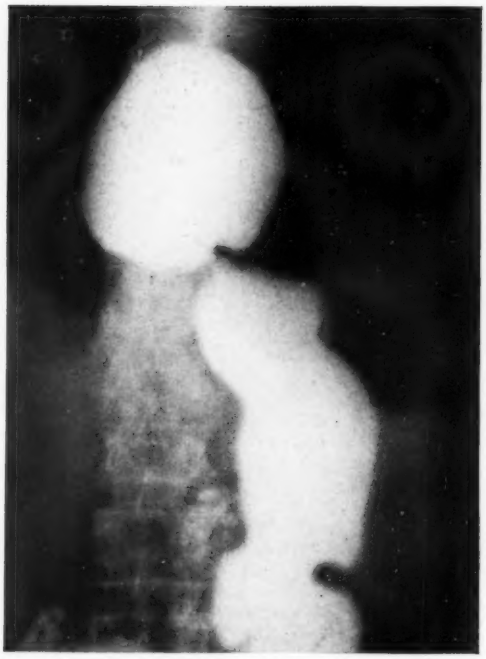


Fig. 15. Case 39. This roentgenogram shows a large herniation. Many of the cases have herniations of this size.

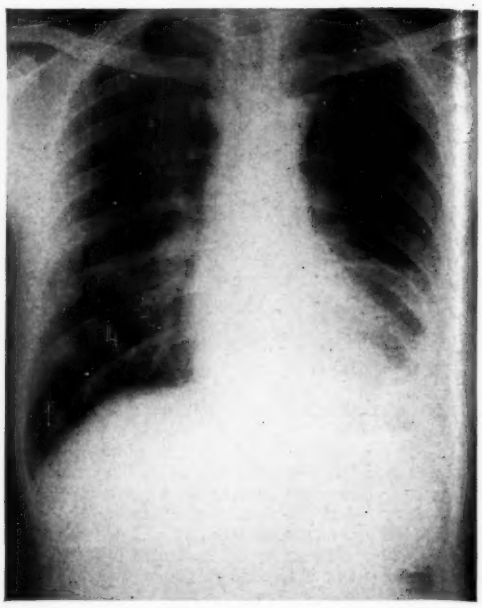


Fig. 16. Case 48. The roentgenogram shows the herniation of the stomach through the diaphragm. It resembles a cystic area in the lower left thorax. A fluid level is seen below the diaphragm on the left.

tension. The gastro-intestinal series showed a large herniation of the stomach through the diaphragm. An operation was performed in which stomach and spleen were returned to the abdominal cavity. There was no ulceration of the stomach and the diaphragm was repaired. Convalescence was uneventful. The patient has been asymptomatic to 1938 (Fig. 13).

Case 16. E.S., No. 3725, a woman, aged 64 years, was admitted to Strong Memorial Hospital on November 3, 1926. Anemia and weakness occurred periodically for 14 years and the onset always followed fatigue. She had been in bed all summer previous to admission. Iron and rest usually were all that were necessary. There was no loss in weight and no gastro-intestinal symptoms. Severe melena occurred 27 years before and there was occasional bleeding from the rectum since. Examination showed a stout, pale, but generally normal individual with severe secondary anemia. Tarry stools were noted. The gastric secretion had a normal acidity but blood was present. The gastro-intestinal series revealed a large portion of the stomach above the diaphragm with a definite constriction which divided the stomach into 2 portions. Her brother also had a diaphragmatic hernia. Exploration was advised and this was done by Dr. Dan Jones in Boston. Herniation was found present without constriction or thickening of the stomach. Nothing else abnormal was found (Fig. 14.).

Occasionally, in spite of the severity of the symptoms, operation will be refused. In such an event treatment must of necessity be symptomatic and is not likely to be effective.

Case 17. E. B., No. 58626, a female, aged 69 years, was admitted to Rochester Municipal Hospital on March 21, 1932, because of abdominal pain and vomiting. The patient had been in good health till December, 1931. Then lower abdominal pain occurred with severe cramps, diarrhea, 10 to 15 stools daily, vomiting for 1 month, burning epigastric pain and belching for 2 weeks. Examination showed the patient to be well developed and nourished with adentia, thoracic kyphosis, emphysematous chest, arteriosclerosis, tenderness in both upper quadrants especially the right, and a palpable mass in the right, upper quadrant. Vomitus contained blood. The gastro-intestinal series revealed a large herniation of the stomach, 6 by 8 centimeters, through the diaphragm. Surgery was advised but was refused. Vomiting continued and there was no improvement on discharge from the hospital.

The majority of patients with esophageal hiatus hernias have puzzling histories. There

Fig. 17. Case 48. The constricted area of the herniated portion of the stomach is well shown. The fluid level shown in Figure 16 is in a subdiaphragmatic diverticulum of the greater curvature of the stomach.

are a good many cases in which only a small knuckle of the fundus is demonstrated during the gastro-intestinal barium study (Fig. 18). The 15 following cases serve to illustrate this type of patient. The symptoms are often severe although the herniation is small. In some cases the herniation undoubtedly was responsible for most of the symptoms; in some cases there were other pathological lesions associated; in some, the demonstration of the hernia was apparently only coincidental.

Cases 18, 19, 20, 21, 22, 23, and 24 have a predominant gastro-intestinal history.

Case 18. L.C., No. 109266, a male, aged 80 years, was admitted to Strong Memorial Hospital on November 17, 1935. The patient gave a history of epigastric pain, belching, cramps with nausea and vomiting for 5 to 6 years. Five days previous to admission diarrhea, melena, and pain occurred. Examination revealed pallor, slight enlargement of the heart, umbilical hernia, liver 2 fingers breadth down, enlarged prostate, hypertension and arthritis. His red blood cells were reduced to 1.25 red blood cells, hemoglobin 4.5 grams. The patient was drowsy but there was a gradual improvement. The gastro-intestinal series revealed a small diaphragmatic hernia, 2 duodenal ulcers. He had spells of bleeding. Final improvement was brought about under medication.

Fig. 18. Case 49. Some small herniations can be demonstrated in the flat plate as extensions of the gas bubble above the diaphragm.

Case 19. E. McK., No. 121043, a female, aged 70 years, was admitted to Strong Memorial Hospital on November 5, 1936. There had been insidious onset of general weakness, anorexia, and insomnia 6 months previously from which the patient recovered somewhat with bed rest. Similar attacks occurred 2 months later with vague epigastric discomfort especially on bending over. There was present

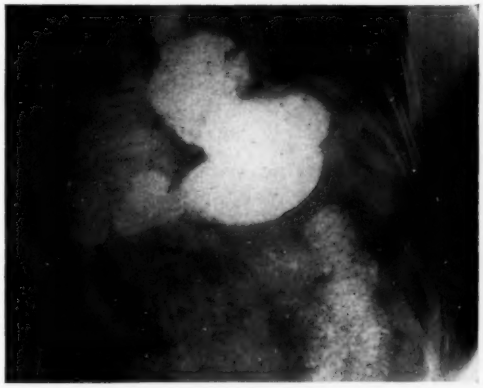


Fig. 19. Case 50. A lateral view sometimes gives an accurate picture of the amount of herniated stomach and its relation to the diaphragm.

Fig. 20. Case 51. Herniations as large as this may not give any evidence of their presence when the patient is standing. Recumbency is necessary to show them.

some nausea but no vomiting. The patient was depressed but well developed and nourished; her teeth were in poor condition, and there was a moderate hypertension. Otherwise her condition was normal. The gastro-intestinal series showed a small herniation through the esophageal hiatus, a small stomach but no ulcers. No symptoms were present while the patient was under medical treatment.

CASE 20. D.C., No. 122879, a male, aged 47 years, was admitted to Strong Memorial Hospital on January 3, 1937. He complained of nervous exhaustion, headaches, weakness and a constant desire to rest, for a period of 7 years. Two months previous to admission he experienced discomfort after eating which was not relieved by milk but was always relieved by soda. He also complained of constipation and had lost 5 to 10 pounds in weight. The patient was poorly developed and nourished with slight exophthalmos and hypotension. Examination was generally negative. The gastro-intestinal series showed a small herniation through the diaphragm at the cardia. The patient complained of pain on inspiration as the herniation occurred. He was discharged for medical treatment.

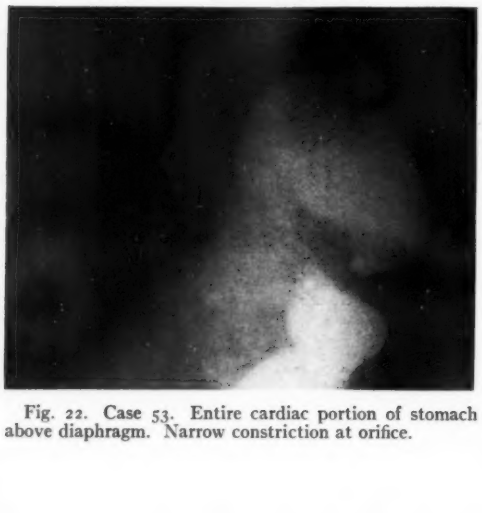


Fig. 22. Case 53. Entire cardiac portion of stomach above diaphragm. Narrow constriction at orifice.

Fig. 21. Case 52. A large portion of the stomach herniates into the thorax in some cases.

CASE 21. R.S., No. 84491, a male, aged 36 years, was admitted to Strong Memorial Hospital on December 2, 1937. For 5 years the patient had suffered distress before meals which was relieved by soda or food. His case was diagnosed as duodenal ulcer here in 1934. When he followed medical instruction, he was free from symptoms. In the last few months he complained of heart burn and vomiting. On the night preceding admission he vomited blood for the first time, and his stool was black. Examination showed a normal individual except for a pilonidal sinus and the presence of blood in stools. There was no anemia. The gastro-intestinal series revealed a small esophageal hiatus hernia which improved rapidly under medication.

CASE 22. No. 127312, a female, aged 54 years was admitted to Strong Memorial Hospital on May 2, 1936. An appendectomy had been performed 3 years previously. The gall bladder was under suspicion at that time as a source of mild epigastric distress. The patient suffered for 1 year with gas immediately after eating which was relieved by belching. There was an increasing discomfort with a sense of crowding below the sternum and occasional precordial pain. Four nights before admission a severe bout of precordial pain radiated down the left arm, lasting 1 hour and requiring morphine. An oral cholecystogram was normal 3 years previously but her physician believed the gall bladder to be the base of her trouble. She was well developed. The gastro-intestinal series revealed a small herniation through the esophageal hiatus, pylorospasm and cardiospasm. There was no duodenal ulcer.

Fig. 23.

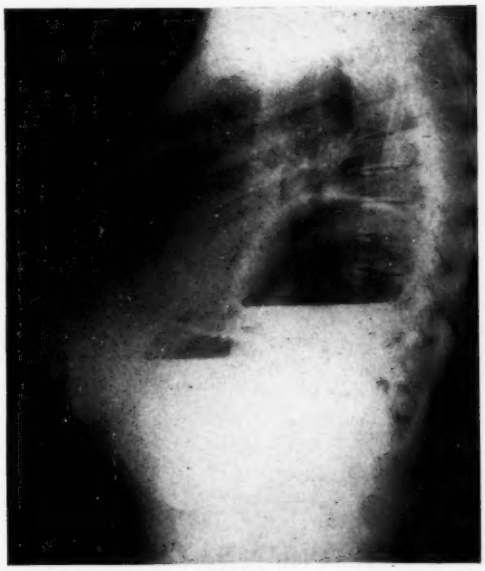


Fig. 24.

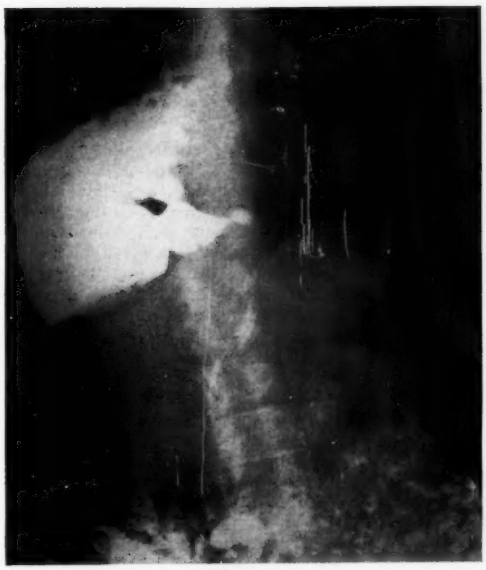


Fig. 25.

Figs. 23, 24 and 25. Case 54. These 3 roentgenograms demonstrate a thoracic stomach. In Figures 23 and 24, 2 pouches are seen. In Figure 23 the lower thorax is occupied by an air and fluid containing cystic area with an extension of a similar area to the left and below the left diaphragm. The right diaphragm is above the stomach. The esophageal opening is to the right of the median line and high up. The whole stomach is between the right diaphragm and above the liver in Figure 25. This must be a freely mobile stomach which passes back and forth through a large defect posteriorly between the right and left leaves of the diaphragm. The right diaphragm represents a true eventration. There is a congenital shortening of the esophagus.

Case 23. W.O., No. 101098, a male, aged 62 years, was admitted to Rochester Municipal Hospital on April 7, 1935, suffering from vomiting, dizziness and weakness. He vomited coffee ground material immediately after waking on the morning of admission. This was followed by nausea and extreme weakness but no pain. He had lost 35 pounds in 6 months. He experienced occasional heart burn which was relieved by soda. He was a heavy drinker, obese, pale, and slightly anemic with tarry stools. The gastro-intestinal series showed a small diaphragmatic hernia. A Sippy diet and rest were prescribed. Stools were guaiac positive for 18 days, and he was discharged in good condition.

Case 24. A. H., No. 120834, a woman, aged 63 years, was admitted to Strong Memorial Hospital on October 23, 1936. Her complaints were heart trouble, stomach trouble and weakness, dropped beats, low blood pressure, poor appetite, frequent nausea and belching for 2 years. The gastro-intestinal series 2 years before were pronounced all right at another hospital. She had been in bed most of the time since, had eaten little and had vomiting spells 2 weeks previously. The general examination was

Fig. 26. Case 55. Spiral twist of stomach which is all above the diaphragm except pyloric end. Multiple pancreatic calculi demonstrated below the stomach, confirmed at necropsy.

negative. She had lost 11 pounds in 2 months. The gastro-intestinal series showed a small hiatus hernia with a duodenal ulcer suspected. Under medication the patient improved.

Case 25 simulates a cardiac complaint.

CASE 25. J. D., No. 29024, a man, aged 69 years, was admitted to Rochester Municipal Hospital on September 8, 1937. On 2 previous admissions coronary occlusion and heart disease were proved by the electrocardiogram. Sharp retrosternal pain radiated to the fingers on the left side after exertion. Heart medication was given and there was a gradual recovery. There are now recurrent pains plus distention, nausea after eating, mild anorexia, with a loss of 7 pounds in weight. The gastro-intestinal series showed a herniation through the middle of the dome of the diaphragm when patient was in Trendelenburg position. The patient complained of pain on deep inspiration and said that this pain was what he ordinarily experienced.

Case 26 illustrates how symptoms may be latent for years in these cases, and then become annoying.

CASE 26. A. P., No. 126460, a man, aged 87 years, was admitted to Rochester Municipal Hospital on April 16, 1937. He had been well till 6 months previously. Then a non-productive cough, shortness of breath, sensation that there was something that caused difficulty in swallowing, hoarseness and loss of weight occurred. Examination showed signs of age and a hypertrophied prostate. Barium showed an esophageal hiatus hernia. On smooth diet and belladonna the patient improved and was discharged for medical care.

Cases 27 to 32 had other associated diseases and small thumb-sized para-esophageal herniations.

CASE 27. G.T., No. 61193, a woman, aged 41 years, had been admitted 15 times to Rochester Municipal Hospital from May 14, 1932 to February 9, 1937. Previous entries were for tertiary syphilis, suspected cholecystitis, right hydronephrosis, double left ureter, pyelitis, cystitis, gynecological complaints, anxiety state, etc. Careful studies failed to reveal a definite organic basis for her numerous complaints. In 1 of her later admissions she complained of nausea, vomiting, and pain in the epigastrium after meals. The gastro-intestinal series showed a small herniation through the esophageal hiatus on deep inspiration. There was also cardiospasm and slight pylorospasm but no ulcer. She was maladjusted, threatened suicide and the social problem was very complicated. She was symptomatically relieved by medication. She was told about her stomach and has had relapses of her symptoms from time to time.

CASE 28. M.O., No. 39464, a woman, aged 77 years, was admitted to Strong Memorial Hospital on November 16, 1936. Eighteen months previously there had been an onset of pain in the right shoulder, generalized later over the back which lasted 2 weeks. This was followed by a persistent non-radiating pain over the entire lower abdomen without nausea or vomiting. Her mother died of carcinoma of the breast and her son had carcinoma of the colon. An appendectomy was performed 10 years previously and a gall bladder operation 27 years before. The patient was obese, with degenerative arthritis and hypertension. The remainder of the examination was normal. The gastro-intestinal series showed a small herniation through the esophageal hiatus, diverticula of the duodenum, and gastric and duodenal ulcers. She was asymptomatic during medical treatment.

CASE 29. E.S., No. 121036, a male, aged 61 years, was admitted to Strong Memorial Hospital on November 4, 1936, suffering with loss of strength and a sore tongue. For 6 weeks there had been puffiness of eyelids, palpitation of heart and pain radiating down the left arm. This was relieved by rest. He had typhoid at 16 years of age, and had a yellowish appearance. When given liver and iron, he improved. Diagnosis revealed pernicious anemia. The gastro-intestinal series showed a small diaphragmatic hernia at the esophageal hiatus, and pylorospasm. He improved under medical care.

CASE 30. A.C., No. 111371, a male, aged 73 years, was admitted to Rochester Municipal Hospital on January 24, 1936, with generalized tuberculosis, pulmonary, intestinal, and peritoneal, and probably

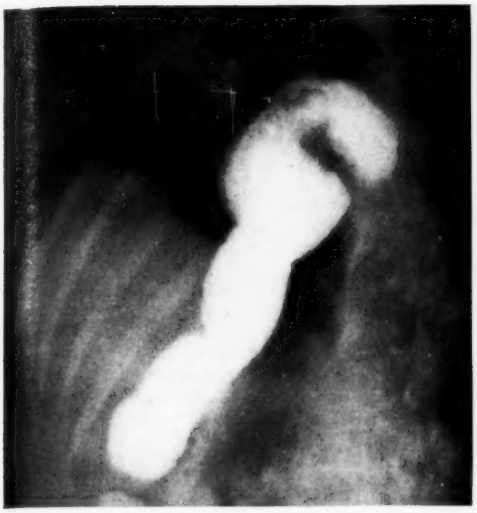


Fig. 27. Case 56. Practically the whole stomach is above the diaphragm in this case. (Three-fourths lateral view.)

Fig. 28. Case 56. The diaphragm level shows well below the thoracic stomach in this view.

of the kidneys also. In the course of his examination a small diaphragmatic hernia was noted at the esophageal hiatus. He died at home the next month.

CASE 31. R.B., No. 25287, a male, aged 61 years, was admitted on May 25, 1930, to Rochester Municipal Hospital, with an impermeable stricture of the urethra. Mineral oil could be passed by the sphincter with little difficulty. Dilatation of stricture following mineral oil led to oil embolism of the lungs and kidneys. The patient died. On postmortem examination a diaphragmatic hernia was found on the left side.

CASE 32. F.M.O., No. 99222, a man, aged 72 years, was admitted to Strong Memorial Hospital on February 13, 1935, with a prostatic obstruction. Two weeks previously there were anorexia, fullness in the epigastrium, gradual onset of nausea following ingestion of food, and constipation. Examination showed a heart slightly enlarged to the left and moderate sclerosis. General examination was normal. The gastro-intestinal series showed a small diaphragmatic hernia. A perineal prostatectomy was performed. He was discharged in good condition and has had no further stomach complaint.

It is not uncommon to note that the whole fundus has herniated through the esophageal hiatus. Cases 33 to 36 are typical examples.

CASE 33. M.S., No. 72433, a man, aged 56 years, was admitted to Rochester Municipal Hospital on May 6, 1937. For 3 to 4 months he had a chronic cough with yellowish sputum, which became bloody in the last 4 days. There were vague anterior chest pains, some night sweats and questionable loss in weight, mild nausea and occasional vomiting. Examination showed the patient to be obese with chronic bronchitis, bronchiectasis, and chronic sinusitis. The gastro-intestinal series revealed a diaphragmatic hernia which consisted of the whole fundus of the stomach. He was discharged for medical treatment.

CASE 34. M.N., No. 60770, a woman, aged 50 years, was admitted 8 times to Rochester Municipal Hospital from May 9, 1932 to October 26, 1937, for gynecological complaints, hypertension, and diabetes. On her sixth admission, February 1937, she complained of diarrhea associated with epigastric pain. This came immediately after eating and lasted 2 to 3 hours, leaving a soreness in the epigastrium. Food aggravated the pain. The gastro-intestinal series showed a large sac of stomach herniated through the diaphragm at the esophageal hiatus and associated pylorospasm. On her last 2 hospital admissions, she complained of no symptoms referable to the epigastrium.

CASE 35. A.P., No. 63663, a woman, aged 63 years, was admitted to Strong Memorial Hospital on June 5, 1936. Six weeks previously she noticed mucus and blood in her stools, also a dull aching in the left, lower quadrant. There had been gas on the stomach and belching but no other gastric symptoms. Examination showed a well developed and nourished individual with arteriosclerosis and mild arteriosclerotic heart disease. Blood was present in the stool. Barium enema was negative; stomach

Fig. 29. Case 57. It is advantageous to demonstrate the end of the esophagus in these cases. It shows well here and it is apparently congenitally shortened. The diaphragm levels are well seen below in this lateral view.

acidity was normal. The gastro-intestinal series revealed no evidence of ulcer or cancer. There was a herniation of the fundus through the esophageal hiatus. She improved under medical treatment and was reassured regarding cancer.

CASE 36. Y.K., No. 30360, a woman, aged 52 years, was admitted to Strong Memorial Hospital on December 4, 1929. Four weeks previously she awakened feeling weak, nervous, and dizzy and these symptoms persisted. Her physician sent her to the hospital because of blood in the stools. Examination revealed varicose veins, hallux valgus, kyphosis, and secondary anemia. The gastro-intestinal series showed a herniation of the cardiac end of the stomach through the esophageal hiatus. There was no evidence of gastric ulcer or cancer. Barium enema was negative. Proctoscopic inspection revealed hemorrhoids only and the patient was discharged for medical care.

Cases 37 and 38 had definite evidence of diseased gall bladders in addition to the gastric complaints.

CASE 37. C.M., No. 70195, a man, aged 53 years, was admitted to Rochester Municipal Hospital on January 12, 1933. He gave a history of stomach trouble dating from typhoid 23 years previously. Ever since he had a dull, heavy feeling in the mid epigastrium, heart burn, belching, occasional nausea and vomiting which gave relief. Discomfort was not relieved by meals but was aggravated instead. He dreaded the thought of eating but had gained in weight in the last 1½ years. When he bent forward he had a feeling that everything would come out of his mouth. Examination showed a man well developed and nourished with slight hypertension and hemorrhoids. The impression was gastric lesion and cholecystitis. The gastro-intestinal series revealed a herniation of the stomach through the esophageal hiatus; the cholecystogram showed chronic cholecystitis. He received symptomatic treatment and improved. He now has occasional attacks of burning which are relieved by soda and diet.

CASE 38. H.S., No. 126260, a male aged 77 years, was admitted to Strong Memorial Hospital on April 3, 1937. He had been well till 3 years previously when he began to lose weight. Six days before admission he felt a sudden, progressively severe epigastric pain coming on while at rest, which radiated over the entire upper abdomen, more to the right than to the left. Later vomiting occurred with tarry black material, and continued nausea. He was afraid to eat and lost weight rapidly. He had a similar attack 20 years before and suffered with typhoid at 45 years of age. There was fullness and tenderness in the right upper quadrant and epigastrium, and blood in the stools. The gall bladder test was positive for stones. He had evidence of myocardial damage. The gastro-intestinal series revealed a large diaphragmatic hernia, and a diverticulosis of the large bowel. Rapid improvement was brought about under medical treatment.

In case 39, the large fundus herniation was discovered when barium was given by mouth to check on the possibility of a partial obstruction of the small bowel. The patient had had a resection for carcinoma of the rectum 1 year previously.

CASE 39. J.M., No. 106067, a woman, aged 67 years, was admitted to Strong Memorial Hospital on August 11, 1936. In August 1935 she had been in the hospital for resection of carcinoma of the rectum. Since discharge she had had cramp-like pains 2 to 3 times a week, located around the umbilicus on the right, followed by diarrhea. She had gained 13 pounds since she was discharged from the hospital. General examination was not remarkable. The colostomy opening was redundant. The gastro-intestinal series showed a diaphragmatic hernia of the stomach through the esophageal hiatus. There was fixation and slight obstruction due to diaphragm spasm. There was no intestinal obstruction in the small bowel. The patient improved under careful regulation of diet and catharsis.

When patients have reached later life and other diseases are actually present, the accu-

rate diagnosis becomes increasingly difficult. In our esophageal hiatus hernias we have noted the presence of the degenerative disease of age (arteriosclerosis, heart, kidney, diabetic, and prostatic conditions), pneumonia, syphilis, cholecystitis, gastric ulcer, cancer of the rectum and colon, and acute appendicitis.

The 4 following cases illustrate these difficulties. The patients all had very serious pathological conditions in addition to the herniation of the fundus. In all cases from Cases 33 to 43 there was as large a portion of the fundus herniated as is shown in Figure 15.

CASE 40. L.G., No. 48186, a woman, aged 60 years, was admitted to Strong Memorial Hospital on January 6, 1934. She was a garrulous Irish woman who would not give a consistent story. One gathered that she had considerable pain in the lower thoracic and upper abdominal regions. It radiated under the sternum, was aggravated by eating, and relieved by hot water. There was also spasm and bleeding from the rectum. The patient also had a cough, with mucopurulent sputum. Examination showed loss of weight, hypertension, an area of dullness at the right base posteriorly with diminished breath and voice sounds, prolapse of the rectum, moderate secondary anemia and no fever. Roentgenograms showed a dense shadow on the right lung extending from the seventh posterior rib to base. The gastro-intestinal series revealed a herniation at the cardiac end of the stomach through the diaphragm. The shadow in the right chest varied in size. The patient remained in the hospital for 3 months and improved under medical treatment. Impression was that there was carcinoma of the lung and a hernia of the diaphragm. She died on May 11, 1937 at her home. The cause of death is unknown.

CASE 41. C.P., No. 128726, a male, aged 46 years, was admitted to Strong Memorial Hospital on June 6, 1937. There had been a gradual onset of gnawing pain in the mid epigastrium, associated with nausea and vomiting for 4 days; vomitus was chocolate colored and blood streaked. Since then vomiting, distention and hiccoughs have continued. Temperature was 100.5; pulse 80; white blood cells, 7,300. The patient was undernourished, pale, dehydrated, and suffered loss in weight. There was a moderate distention and tenderness in the left para-umbilical region. The stool was guaiac plus; gastric analysis was also guaiac plus. The gastro-intestinal series revealed a 6 centimeters diaphragmatic hernia of the stomach with spasm of the pylorus and palisading of the small bowel. He was observed six days but there was no improvement. Exploration showed a gangrenous appendix and generalized peritonitis. Death followed 5 days after operation.

CASE 42. R.T., No. 117284, a male, aged 78 years, was admitted to Rochester Municipal Hospital on July 21, 1936. The patient gave a history of occasional mild substernal pain with cough, hemoptysis, night sweats, weakness, loss of weight, emaciation, and cyanosis. There were a few râles at both bases, otherwise the lungs were normal. Roentgenogram revealed a probable infiltrating carcinoma of the right lower lobe. The gastro-intestinal series showed a herniation of the fundus of the stomach through the esophageal hiatus with fixation within the thorax. The patient died in August, 1936. Autopsy showed organizing pneumonia, pyelonephritis, and general arteriosclerosis.

CASE 43. A.S., No. 82548, a female, aged 57 years, was admitted to Strong Memorial Hospital on November 22, 1933. She entered because of acute urinary retention. Cystitis with a narrowing of the urethra was found. She also had a change in bowel habits, 6 to 8 months of increasing constipation and blood in the stools. Barium enema was negative; the proctoscope revealed hemorrhoids. The gastro-intestinal series showed delay and herniation of the stomach wall through the esophageal hiatus. The patient was readmitted on August 19, 1935, with increasing constipation, vomiting, pallor, and distention. Barium enema was again negative. After exploration showed carcinoma of the hepatic flexure, a cecostomy was performed. Death occurred on the following day.

The presence of syphilis in some of these patients may also render an accurate evaluation of symptoms difficult. Five such examples are here given.

CASE 44. M.M., No. 89744, a woman, aged 24 years, was admitted to Rochester Municipal Hospital on May 20, 1934, because of vomiting, loss of appetite, loss of strength, and a loss of 20 pounds in weight during the previous month. This followed an attack of influenza. Examination was negative except for slight anemia; Wassermann was 4 plus; cholecystogram was normal. The gastro-intestinal series revealed a small hernia through the esophageal hiatus. There was a gradual improvement under medical treatment.

CASE 45. H.M., No. 89022, a male, aged 44 years, was admitted to Strong Memorial Hospital on May 6, 1934, because of vomiting. For 8 to 9 years the patient suffered with epigastric oppression which was relieved by soda and eructations. He had been well till 5 days previously, then nausea set in, which was relieved by soda, but he had been vomiting repeatedly since. He had had chancre 15 years before and occasional transitory pains in the heels; Wassermann was 2 plus. At examination findings were normal. The gastro-intestinal series revealed a hernia of the stomach through the diaphragm but no ulcer. Under rest, diet, and drugs he became symptom free and was discharged. The patient returned in 5 days with a recurrence which was again controlled when he was put on an antiluetic treatment.

CASE 46. F.K., No. 25149, a male, aged 57 years, was admitted to Strong Memorial Hospital on June

3, 1929. He gave a history of mid epigastric pain for 3 months, a dull, steady, nearly constant pain sharply localized high in the mid epigastrium. Occasionally it was parasternal, given to acute exacerbations, which was precipitated by varying postural changes, and relieved in the same manner and by rest. Examination showed enlarged glands, slightly enlarged heart, moderate sclerosis, pupils sluggish to light, arthritis especially of the dorsal spine, and Wassermann 4 plus. The gastro-intestinal series revealed a hernia through the esophageal hiatus. Pain was controlled largely by antiluetic treatment. Occasional attacks like indigestion lasted 1 hour.

CASE 47. M.B., No. 122835, a woman, aged 40 years, was admitted to Strong Memorial Hospital on December 28, 1936. At a previous admission in February, 1936, examination revealed a mild, toxic, nodular goiter. Since then there had been symptoms of indigestion, gas, occasional right upper quadrant pain, palpitation, and transient dizziness. Improvement was brought about with belladonna. The patient was nervous, emotional, with a large thyroid, but otherwise was normal physically. Wassermann tests on 3 occasions were one plus, two plus and negative respectively. The gastro-intestinal series showed a small diaphragmatic hernia at the cardia. The patient complained of pain on deep inspiration as the stomach herniated. There were associated cardiospasm and pylorospasm. She was put on medical treatment with still persisting mild symptoms.

CASE 48. J.B., No. 1736, a male, aged 52 years, was admitted to Strong Memorial Hospital on July 7, 1926. For 3 years the patient had a run down feeling and in June, 1925, had to give up work, because he was weak and anemic. He was treated for pernicious anemia until January, 1926, but there was a gradual decline through winter with vague stomach and chest pains. The patient had had chancre 32 years previously. Patient was sallow, and had peculiar rumbling sounds over the precordium. There was a percussion note at times tympanitic over the heart region, splashes and clicks synchronous with heart beat, tenderness in the epigastrium, and absence of knee jerks and secondary anemia; Wassermann 4 plus. The gastro-intestinal series showed a diaphragmatic herniation of stomach and diverticulum of stomach below the diaphragm. The patient was put on antiluetic treatment and improved.

In Case 48 the roentgen ray demonstrated a very unusual picture. In addition to the large intrathoracic sacculation, which appeared like a cystic area in the lower left chest, there was also a diverticulum extending laterally from the greater curvature below the diaphragm Figs. 16 and 17.

The diagnosis can be suspected from the symptoms and signs. It is clinched by the roentgen examination. Barium may be necessary in a gastro-intestinal series or in a clysma in order to show the lesion. The esophageal hiatus hernias can be noted occasionally in the upright position, but usually the lesion is much more pronounced when the patient is reclining. It may even require deep inspirations to demonstrate the small portion of the cardia above the diaphragm. Sometimes the air bubble will be sufficient to outline the herniation (Fig. 18). As a rule a swallow of barium demonstrates the lesion accurately. This must be differentiated from cardiospasm, and diverticulum of the esophagus. It is simplified when the rugæ of the cardia can be traced directly into the sacculation across the intervening diaphragm which causes a constriction about the area (Fig. 12). It is often surprising how large a portion of the stomach can be demonstrated above the diaphragm when the patient is prone, only to have it completely subside below the diaphragm level on standing (Fig. 20).

Esophagospasm (Fig. 11) and cardiospasm are often associated, and frequently pylorospasm as well. This makes the diagnosis of intramural gastric lesions difficult. The barium by mouth will many times give definite fluid levels, indicating the partial stasis which is present in some of these stomachs (Figs. 13 and 14). Transition to the true thoracic stomach can be determined only by demonstration of the length of the esophagus. If it is present and curled back upon itself so that the stomach could be put back below the diaphragm if necessary, the case is a true hiatus hernia (Fig. 11). In the true thoracic stomach the esophagus is congenitally shortened, making subdiaphragmatic restoration of the stomach impossible. Consequently, it is important to visualize completely the esophagus in all these patients. Some hiatus hernias contain a large portion of the stomach (Figs. 21 and 22). Cases 49 to 53 show the radiographic appearances described above.

CASE 49. G.R., No. 120760, a woman, aged 67 years, was admitted to Strong Memorial Hospital on October 30, 1936. She had had jaundice with fever at 19 years of age. Appendectomy had been performed 12 years previously. Her present admission was concerned with attacks of bronchitis. There were no symptoms referable to the stomach. Examination

showed chronic bronchitis, emphysema and arteriosclerotic heart disease. In the course of her examination, a diaphragmatic hernia through the esophageal hiatus was noted. It was chiefly seen on deep inspiration, on coughing or straining. She was asymptomatic in the hospital (Fig. 18).

CASE 50. B.D., No. 23844, a woman, aged 58 years, was admitted to Strong Memorial Hospital on March 6, 1935. Two years previously she had complained of increasing fatigue, gain in weight, shortness of breath on stair climbing, also attacks at night in which she feared death. These attacks consisted of severe lancinating pains and soreness of the right costal margin. After large meals there was indigestion with pressure upward on the left side which could be relieved by belching. Several months before she developed a dull, non-radiating pain in the left upper quadrant. It was more marked on exertion and on lying down. If it came on in recumbency, she got some relief by getting up. The condition gradually grew worse. Examination showed moderate anemia and obesity. The gastro-intestinal series revealed a large para-esophageal hernia and possible gastric ulcer. She had been comfortable under medical regimen (Fig. 19).

CASE 51. D.B., No. 21060, a woman, aged 77 years at last admission, was first admitted to Strong Memorial Hospital on January 11, 1929. She has had 4 admissions since, mainly for cardiac and diabetic complaints. She was thought to have chronic cholecystitis because of resistance and tenderness in the right upper quadrant. Cholecystogram was within normal limits. The gastro-intestinal series showed a herniation of the upper portion of the stomach through the esophageal hiatus. It produced no motility disturbance (Fig. 20).

CASE 52. C.K., No. 72927, a woman, aged 67 years, was admitted to Rochester Municipal Hospital on March 20, 1933, for frequency, dysuria, and pain in the right side which lasted 4 months. Stereopyelogram showed ptosis of the right kidney with hydronephrosis, and double ureter on the left side. For 25 years she had had attacks of severe epigastric pain and vomiting. The pain grew worse at night and was somewhat relieved by lying on the left side. A cholecystectomy had been performed 27 years previously. Examination revealed an emphysematous chest, hypertension, a scar in right upper quadrant, and a palpable right kidney. The gastro-intestinal series showed herniation of a large portion of the stomach through the esophageal hiatus. Symptomatic treatment only was given (Fig. 21).

CASE 53. M.B., No. 48659, a woman, aged 66 years, was admitted to Strong Memorial Hospital on June 24, 1931, because of weakness, anemia, excessive gas, and constipation for 1 year. There had been occasional icterus and clay colored stools, also sharp pain under the right costal margin and into the low back. The patient had lost 15 pounds in weight and had had colitis and dysentery for 5 years. Examination revealed the patient to be overnourished with moderate anemia, slight enlargement of the heart, mild hypertension, and guaiac positive stools. The gastro-intestinal series showed the entire cardia through the diaphragm. Medical treatment gave relief (Fig. 22).

The partial thoracic stomach which extends through the esophageal hiatus may also give puzzling signs. In consequence, diagnosis of pulmonary cavity, pleural fluid, thickened pleura, bronchiectasis, pneumonia, mediastinal tumor and pulmonary carcinoma have been made in these cases.

The roentgenogram again furnishes the complete evidence and often demonstrates a bizarre arrangement of the organs in the thoracic cavity. Case 54 is a typical example of a thoracic stomach. The flat plate shows a large cystic area in the lower right thorax. It has a fluid level. The lateral view shows it to be 2 gastric pouches; and the barium demonstrates that the whole stomach occupies the right lower thorax. The greater curvature of the stomach is to the right and the cardia, pylorus, and lesser curvature toward the medial side.

CASE 54. B.R., No. 98019, a woman, aged 46 years, was admitted to Rochester Municipal Hospital on October 16, 1936. She had had gaseous indigestion for 4 years, and 2½ years previously nausea and vomiting occurred 1 hour after meals. This condition was relieved somewhat by soda. There was an increasing burning pain in the epigastrium. In the past 2 years she had lost 30 pounds in weight and felt full after she had taken a small amount of food. She had received treatment without avail. For 24 years she had suffered with rheumatism and had well developed, crippled joints, an enlarged thyroid, and moderate hypertension. There was a dull percussion note in the right lower lobe, posteriorly; breath sounds were diminished; vocal fremitus and tactile fremitus were present in the same area, and there was a splashing sound heard after shaking the chest. Laboratory findings were negative. A diagnosis suggested stomach ulcer or cancer and right pleural effusion. The gastro-intestinal series showed a right-sided intrathoracic stomach with a large out-pocketing along the lesser curvature, probably a diverticulum. Medical treatment was advised (Figs. 23, 24, 25).

Case 55 illustrates the rotation of a major portion of the stomach in the thoracic cavity with only a small portion of the pyloric end subdiaphragmatic.

CASE 55. T.N., No. 110808, a woman, aged 61 years, was admitted to Rochester Municipal Hos-

pital on January 10, 1936. She had lost 50 pounds in 6 months. Five months previous she had had a watery diarrhea, associated with nausea, bloating, and loss of appetite. There was extreme weakness, palpitation, dyspnea, and spots before the eyes. Three weeks before admission she had a second bout of diarrhea with blood in stool, and had fainted several times recently. At 15 years of age she had typhoid and had an appendectomy performed 30 years previously. Examination revealed pallor, pyorrhea, moderate distention, severe secondary anemia, complete achlorhydria, chronic cholecystitis (intravenous cholecystogram), and pancreatic calculi. The gastro-intestinal series showed short esophagus, cardia of the stomach above the diaphragm, body of the stomach curled upward for 15 to 20 centimeters behind the heart and to the right of cardia portion, then downward and to the left through the diaphragm. Only one-fifth to one-sixth of the entire stomach was below the diaphragm. She gradually became worse. Ascites developed with thrombosis of the left iliac. Death occurred on March 3, 1936. Anatomical diagnosis revealed multiple pancreatic calculi with complete atrophy; tuberculosis of the peritoneum, diaphragm, left pleura, spleen, and right adrenal; multiple pulmonary emboli; and herniation of the stomach through the diaphragm (Fig. 26).

Cases 56 and 57 show further variations in these gyrating, twisting, gastric herniations above the diaphragm.

CASE 56. A. W., No. 116904, a woman, aged 72 years, was admitted to Strong Memorial Hospital on August 2, 1936. The patient gave a history of pain in the stomach and right upper quadrant with a sudden onset 8 years previously of spells of nausea and persistent vomiting repeated frequently since. There was a swelling in the right epigastrium at onset and at varying intervals. There was also much pain, which was relieved by vomiting. Vomitus contained blood and stools were tarry. She was unable to retain solid food. Her last severe attack occurred 6 months before. The patient lost 18 pounds in 2 years. Examination revealed the patient to be senile with general arteriosclerosis, hypertension, arteriosclerotic heart disease, and tenderness in the epigastrium. The gastro-intestinal series showed herniation of the stomach through the esophageal hiatus, 6 centimeters of fundus above the diaphragm, irreducible, and marked pylorospasm. There was a suggestion of ulceration at the level of the diaphragm and also in the duodenum. Owing to age and general poor condition, phrenic nerve block was done under local anesthesia. She did not have any improvement following this therapy. There were many unrelated aches and pains in all parts of the body (Figs. 27, 28).

CASE 57. M.L., No. 127376, a female, aged 55 years, was admitted to Strong Memorial Hospital on May 10, 1937. Three years before there was an onset of severe epigastric pain during meal or immediately after, which was relieved by drinking water or by vomiting. This occurred once or twice a week with belching and flatulence. Roentgenogram showed a diaphragmatic hernia and diverticula in the large bowel. Medical treatment was administered but symptoms increased. Occasional pain radiated to the left shoulder. Examination was essentially normal. The gastro-intestinal series showed about three-fourths of the stomach intrathoracic and posterior with pinch cock action at the lower end of the stomach. A left phrenic nerve crush was employed and the patient obtained some relief (Fig. 29).

The esophageal hiatus type may be very difficult surgery. It may require approach through the chest or from the abdominal side. Sometimes, even when approached from both angles, it is practically impossible to visualize a small sac. In such a case, packing may be successful in causing adhesions with relief of symptoms. Case 58 is an example.

CASE 58. S.H., No. 62859, a woman, aged 43 years, was admitted to Strong Memorial Hospital on July 6, 1932. For 6 years she suffered attacks of vomiting accompanied by knife-like pain in the left upper quadrant, radiating to the infrascapular region. Attacks occurred usually at night, lasting several hours. These were accompanied by a bloated feeling in the epigastrium and severe eructations. Cholecystectomy and appendectomy were performed 4 years previously with relief for 3 months. For the last 4 years she had been vomiting nightly with severe colic-like pains. She obtained no relief from food or soda and there was blood in the vomitus occasionally during the last 6 months. A diagnosis of duodenal ulcer was made 1 year before. Examination revealed the patient to be very obese. There was gas gurgling and she was belching almost continuously. The gastro-intestinal series was negative except for herniation of the stomach through the esophageal hiatus. Operation was performed by abdominal route, by transthoracic and by both. It was impossible to visualize the opening though it could be palpated. Drains were inserted into it from the abdominal side. Nausea and vomiting disappeared and the patient could eat anything. She has had relief from her symptoms since discharge from the hospital.

The operation described by Harrington is very useful (14, 15). Temporary paralysis of the diaphragm greatly facilitates the task of repair. The edges should be approximated with care. It is not necessary to suture into the esophagus if the repair is properly carried out. Truesdale has given some excellent advice in this regard (23). The passage of a

catheter through the hernia opening to equalize the pressure was suggested by Mayo. It is a useful procedure in a difficult case.

Minor types of esophageal hiatus hernia may be relieved by simple phrenic nerve block though this is not always successful. This method is also applicable to very old or debilitated patients who will not stand a procedure of greater proportions. Care should be taken to determine just what position the stomach and esophageal junction will assume. In case this is not done the angulation between the esophagus and the stomach may be increased and the symptoms may become worse. The excellent studies of Lichtenstein on this question should be known to surgeons contemplating this procedure. At times the right phrenic probably should be the nerve temporarily paralyzed (19).

In some cases of thoracic stomach in which there is a pinch-cock action of the edges of the diaphragm on the herniated organ, a phrenic block will give relief (Case 57). In other cases, no benefit follows this procedure (Case 58).

When the spleen is adherent inside the sac of an esophageal hiatus hernia, it may tear easily if handled while the respiratory excursions are greatly forced. This forms a complication which may be very serious. The spleen should either be sutured if possible (Case 14) or removed if necessary under such circumstances.

BIBLIOGRAPHY

The bibliography is abridged to those references which proved most useful to the author in preparing this paper.

1. Akerlund, A. Hernia diaphragmatica Hiatus oesophagei vom anatomischen und roentgenologischen Gesichtspunkt; Oehnell, H., Klinischen Gesichtspunkt; Key, E., Therapeutischen Gesichtspunkt, Kasuistik, Literaturverzeichnis. Acta Radiol., 1926, 6: 3–68.
2. Bowen, A. Volvulus of an inverted intrathoracic stomach complicating diaphragmatic hernia. Am. J. Digest Dis., 1937, 3: 923–928.
3. Brown, S. The roentgenologic study of the diaphragm. J. Am. M. Ass., 1931, 97: 678–682.
4. Christiansen, H. A Case of hematemesis in an infant due to esophageal orifice hernia. Acta. Radiol., 1937, 18: 77–80.
5. Clerf, L. F., and Manges, W. F. The congenitally short esophagus. J. Am. M. Ass., 1934, 102: 2008–2012.
6. Clopton, M. B. Eventration of the diaphragm. Ann. Surg., 1923, 78: 154–163.
7. Donovan, E. J. Congenital diaphragmatic hernia. Ann. Surg., 1938, 108: 374–388.
8. Dwyer, M. F. Hernia of cardiac end of stomach through diaphragm. Radiol., 1937, 28: 315–324.
9. Friedenwald, J., and Feldman, M. Report of an interesting type of diaphragmatic hernia of the cardia of the stomach through the esophageal orifice. Am. J. M. Sc., 1925, 170: 263–271.
10. Garraud, R., and Bastien, P. Hernies des viscères abdominaux à travers les orifices normaux du diaphragme (Hernies Diaphragmatiques Vraies de Adams). Ann. d'anat. path., 1936, 13: 603–622.
11. Gillespie, J. B. Congenital shortening of the esophagus. J. Pediat., 1936, 8: 38–40.
12. von Greyerz, W. Hernia diaphragmatica retrosternalis. Acta. Radiol., 1937, 18: 428–438.
13. Harrington, S. W. Diaphragmatic hernia associated with traumatic gastric erosion and ulcer. Surg., Gynec. & Obst., 1930, 51: 504–521.
14. Idem. The diagnosis and treatment of diaphragmatic hernia. J. Thoracic Surg., 1931, 1: 24–43.
15. Idem. Diaphragmatic hernia. J. Am. M. Ass., 1933, 101: 987–994.
16. Hedblom, C. A. Diaphragmatic hernia. J. Am. M. Ass., 1925, 85: 947–953.
17. Kerr, H. D., and Steinberg, S. S. Right-sided diaphragmatic hernia. Am. J. Roentgenol., 1935, 34: 735–739.
18. Lemaitre, L. Hernie diaphragmatique du colon transverse. L'Echo med. du nord, 1930, 34: 49–52.
19. Lichtenstein, H. Form- und Lageveränderungen des Magens nach Phrenicusexairese. Beitr. z. Klin. d. Tuberk., 1932, 80: 509–522.
20. Orr, T. G., and Neff, F. C. Diaphragmatic hernia in infants under one year of age treated by operation. J. Thoracic Surg., 1936, 5: 434–440.
21. Thomas, C. C. Non-traumatic diaphragmatic hernia with report of case of congenital right-sided hernia. Radiol., 1937, 28: 608–613.
22. Truesdale, P. E. Diaphragmatic hernia in children with a report of thirteen operative cases. New England J. Med., 1935, 213: 1159–1172.
23. Truesdale, P. E. Diaphragmatic hernia. Am. J. Surg., 1936, 32: 204–216.
24. Woolsey, J. H. Diaphragmatic hernia. J. Am. M. Ass., 1927, 89: 2245–2248.

EXPERIMENTAL TRAUMATIC SHOCK. FURTHER STUDIES WITH PARTICULAR REFERENCE TO THE RÔLE OF THE NERVOUS SYSTEM

ALFRED BLALOCK, M.D., F.A.C.S., and RALPH D. CRESSMAN, M.D., Nashville, Tennessee

MUCH experimental work has been done on the shock that is associated with trauma to an extremity. This method (5) is of particular value in that the opposite extremity may be used as a control and the loss of blood into the injured part may be determined (2). Unfortunately in some instances, the results of such experiments have been interpreted by the investigator himself, or more often by the reader, as explaining all types of shock. This has led to confusion as there are several types of shock and all instances cannot be explained satisfactorily by one theory. The terms hematogenic, neurogenic, and vasogenic have been suggested (3) as names for the different types. Many instances of shock are probably combinations of 2 or all of these.

The 3 most popular theories at the present, as to the causation of shock, maintain that it is due to toxemia, to local fluid loss or to nervous stimuli. It is likely that all 3 of these agencies enter into the production and maintenance of some cases of shock. The most important point is to determine the agency or agencies responsible for the development of shock as there are probably countless factors which serve to maintain it after it is fully developed. If our remarks are limited to the shock that follows severe trauma to an extremity of an experimental animal, it would seem from many recent experiments that toxemia as an important initiating factor has been excluded. Dale stated recently, "With regard to the possible rôle of histamine, we know now what we did not know then, that of all the major tissues of the body, the muscles contain least of that substance. Whatever else it may have been, the shock following the Bayliss-Cannon limb trauma was not histamine poisoning." However, this does not mean that the possibility of the absorption from injured tissues of substances which act slowly and over a long period has been excluded. There is good evidence that deaths which occur a number of days following burns are due in part at least to the action of toxic products.

It was found by Blalock (2) and by Parsons and Phemister that severe trauma to an extremity of a deeply anesthetized dog was associated with the loss of a sufficient part of the blood volume into and near the traumatized area to account for the decline in the blood pressure. These findings have been confirmed by Freedlander and Lenhart, by Holt and Macdonald and by others. Freedlander and Lenhart in their experiments used cats anesthetized by the intramuscular injection of sodium barbital in which the degree of injury was carefully controlled. They state, "With this large series as a control, experiments were conducted to exclude all the nervous connections of the extremity to be traumatized. In order to accomplish this, recovery experiments were done in stages, cutting the cord, the peripheral nerves, and the sympathetic chain. These completely denervated limbs responded to trauma like the controls. . . . The shock following trauma can be explained on the basis of hemorrhage and local fluid loss."

Simonart concluded as a result of experiments on cats that an intact nerve supply is essential for the development of traumatic shock. Recently, O'Shaughnessy and Slome have performed many experiments on cats anesthetized by chloralose. The trauma con-

From the Department of Surgery of Vanderbilt University. Aided by a grant from the Division of Medical Sciences of the Rockefeller Foundation.

Submitted for publication September 19, 1938.

Presented in Round Table Conference before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

sisted of 20 blows to 1 thigh with a heavy iron bar, the femur being broken. In their paper (15) in 1935, they state, "Our first conclusion is that a toxemia, due to the elaboration of histamine or any other depressor substance manufactured in the traumatized area, plays no part in the syndrome of traumatic shock. We regard the 2 remaining factors, local fluid loss and the discharge of nociceptive nervous stimuli, as the effective etiological agents. The evidence does not allow us to dogmatize as to the relative importance of these factors, although we are inclined to believe that the nervous factor dominates the picture." In a later communication (18), they state, "The initial depressor effect of trauma is due to fluid loss; the significant secondary decline to shock is caused by the continued and continuous discharge of nervous impulses from the traumatized area. The nervous factor alone can cause death. The fluid loss in these experiments, provided the nervous factor is controlled, is not fatal." Their methods differ in the main from those of others in that chloralose was used as the anesthetic and the blows were inflicted with an iron bar rather than a hammer or mallet.

Of the many types of experiments performed by O'Shaughnessy and Slome, the two following types seem to be the most significant. It was found that the induction of spinal anesthesia has a most favorable influence in delaying and even preventing the onset of shock in cats anesthetized by chloralose. Second, they found that shock followed trauma to an extremity of an animal in which the limb received its circulation from a second cat. Bell, Clark, and Cuthbertson were unable to repeat these latter findings on cats anesthetized by nembutal. They state, "In none of the experiments was there any evidence that traumatization of the recipient's transfused limb caused anything but a temporary disturbance of the recipient's blood pressure. This is directly opposed to the finding of O'Shaughnessy and Slome. In their 2 recorded cross-circulation experiments, the recipients went into shock and died, and in 1 they found that trauma caused death of the donor some 2 hours after the injury and actually before the recipient went into shock."

A number of experiments have been performed previously which may have a bearing on their observations on the use of spinal anesthesia. Parsons and Phemister found that the traumatization of denervated limbs of dogs resulted in low blood pressures similar to those produced in animals whose limbs were not denervated. As stated, Freedlander and Lenhart obtained similar findings in cats. Blalock (4) found that trauma produced its characteristic effects in dogs after spinal anesthesia had been induced. Holt and Macdonald (12) have found no evidence which supports the view that nociceptive nervous stimuli from the injured tissues dominate the picture in dogs anesthetized with sodium barbitone.

The present investigation consists of an attempt to assess the parts played by fluid loss and by nervous impulses in the onset of shock due to trauma. As stated, O'Shaughnessy and Slome used chloralose as the anesthetic and therein may rest the explanation for the discrepancy between their results and those of others. For this reason, the effects of the same procedures under chloralose and under nembutal anesthesia have been compared. It may not be amiss at this point to quote several authorities on the properties of chloralose. Cushny (7) states that chloralose is a sugar compound of chloral which acts much more like morphine than like chloral. It depresses the psychical functions while increasing the reflexes until convulsions resembling those of strychnine may be produced. Sollman states that chloralose is often contaminated with non-hypnotic but toxic parachloralose. It is stated in the *United States Dispensary* (20) that the action of chloralose is variable and that it may produce collapse, convulsions, or pronounced disturbances of respirations.

METHODS AND RESULTS

The experiments were all performed on cats or dogs and chloralose or nembutal was used as the anesthetic. The anesthetic was introduced intravenously. The initial dosage per kilogram of body weight of chloralose was 0.08 grams and of nembutal was 0.025 grams. In the course of the experiment additional doses were given as required. There was no

evidence of pain during the course of the experiments. The arterial blood pressure was determined in most instances by the use of a carotid cannula which was connected to a mercury manometer. In the remaining experiments, the exposed carotid artery was punctured with a needle which was connected to a manometer. The trauma consisted of striking the thigh with an iron bar, as used by O'Shaughnessy and Slome, thus breaking the femur. The increase in the weight of the traumatized extremity was determined by the amputation method (2) which was described previously by one of us. In the experiments in which spinal anesthesia was induced, the fluid was introduced intrathecally in the lower lumbar region. The dosage of the spinal anesthetic was the same as that used by O'Shaughnessy and Slome (15), namely, 1.66 milligrams novocain in .03 cubic centimeters of water per kilogram of body weight. The methods used in the cross-circulation experiments were similar, to those employed by O'Shaughnessy and Slome (15). The distal ends of the divided femoral artery and vein of 1 animal (recipient) were anastomosed by suture to the proximal ends of the carotid artery and external jugular vein of a second animal. The extremity of the recipient was then rendered *anemic* by the method of O'Shaughnessy and Slome, namely, ligation of the abdominal aorta, iliolumbar artery, middle sacral, external iliac, profunda femoris, the femoral artery and its branches in the groin and the veins corresponding to these arteries. Following this, the clips were removed from the vessels which had been connected by suture and the extremity was traumatized. According to O'Shaughnessy and Slome, the traumatized extremity receives blood only from the second animal and yet the reflexes are maintained intact.

Several different groups of experiments were performed.

GROUP I. CATS: TRAUMA, WITH AND WITHOUT SPINAL ANESTHETIC

Chloralose. These experiments were performed in pairs. Both cats received chloralose and 1 of the 2 received a spinal anesthetic before and at 30 minute intervals following the traumatization for a period of 7 to 8 hours. The trauma consisted of 20 blows with an iron bar thus breaking the femur. Sixteen cats were used in this study, thus making 8 complete experiments in which animals with and without the spinal anesthetic were compared. The animal with the spinal anesthetic lived longer than the control animal in 6 of the 8 experiments; the reverse was true in 1 experiment and there was no difference in the remaining 1. There seemed to be little doubt that cats anesthetized with chloralose withstand trauma to a posterior extremity better if a spinal anesthetic is administered before and following the trauma. The results in the 16 experiments were as follows: Three of the cats with the spinal anesthetic were killed 25 or more hours following the traumatization. The blood pressure of only 1 of these was markedly depressed. The average survival of the 5 remaining was 18 hours and 50 minutes and the average fluid loss in these equalled 3.11 per cent of the body weight. Of the cats without spinal anesthesia, 1 had a normal blood pressure 26 hours after the traumatization and was killed. The average survival of the 7 remaining was 13 hours and 13 minutes and the average difference in weights of the traumatized and non-traumatized extremities equalled 3.26 per cent of the body weight. A moderate decrease in the concentration of the red blood cells was found in most of the experiments.

O'Shaughnessy and Slome found that the giving of a spinal anesthetic to cats already in shock as a result of trauma increased the survival period. These experiments were repeated on 5 pairs of cats. Shock was produced in the usual manner. After the blood pressure reached a shock level, 1 cat in each group was given a spinal anesthetic and this was repeated every 30 minutes. There was no difference in the survival period of the 2 cats in 2 of the 5 experiments; the cat without spinal anesthesia survived longer than the other in 2 of the experiments and the reverse was true in the remaining experiment. The experiments do not support the contention that a cat already in shock is benefited by the giving of a spinal anesthetic. The average difference in the weights of the traumatized

and non-traumatized extremities in the animals which received spinal anesthesia was 2.87 per cent of the body weight while that in those without the spinal was 3.59 per cent. A decrease in the concentration of the red blood cells occurred in most of the experiments.

As has been stated, the blood pressure in these experiments was determined by puncturing intermittently the exposed carotid artery with a needle which was connected to a mercury manometer. Cats survive longer as a rule when this method is used instead of placing a cannula in the carotid. This may be due to the loss of blood that occurs when it is necessary to wash out the cannula due to the clotting of blood.

Nembutal. There were 16 experiments of this type on cats anesthetized by nembutal. Trauma in all instances consisted of 20 blows with an iron bar thus breaking the femur. The blood pressure was determined in the carotid artery by the needle puncture method. Eight animals served as controls and the other 8 were given spinal anesthesia before the trauma and every 30 minutes afterward for 7 or 8 hours. Six of the 8 animals which received no spinal anesthesia were alive at the end of 24 hours and were killed. The blood pressure was definitely depressed in 2 of these. One of the 8 died 4 hours and 35 minutes following the trauma and the remaining animal lived 22 hours and 30 minutes. The animal with the short survival period was extremely anemic, the control hematocrit reading being 17 and it declined to 13. The average difference in the weights of the traumatized and non-traumatized extremities in the 7 experiments in which it was determined equalled 3.55 per cent of the body weight. Six of the 8 animals that received a spinal anesthetic were alive at the end of 24 hours and were killed. The blood pressure was definitely depressed in 3 of these. The 2 remaining animals died 21 hours following the trauma. The average difference in the weights of the traumatized and non-traumatized extremities in the 6 experiments in which it was determined was 3.03 per cent of the body weight. The results in the 2 types of experiments, with and without a spinal anesthetic, were practically identical. There was very little alteration in the hematocrit reading in 11 of the 16 experiments, a moderate rise in 1 and a moderate decline in 4.

GROUP II. DOGS: TRAUMA, CHLORALOSE, WITH AND WITHOUT SPINAL ANESTHETIC

As has been stated, O'Shaughnessy and Slome produced shock in cats by striking the thigh 20 blows with an iron bar thus breaking the femur. This method was used in our first 6 experiments on dogs anesthetized by chloralose. Two of the animals did not develop shock and were killed approximately 26 hours subsequently. The average survival of the 4 remaining animals was 9 hours and 45 minutes, the time ranging from 55 minutes to 20 hours. The difference in the weights of the 2 extremities ranged from 3.14 to 5.23 per cent of the body weight, the average being 4.19 per cent. Fourteen experiments were then carried out in which the traumatization consisted of 40 blows with an iron bar, the femur being broken. Two of these animals were not in shock 23 hours subsequently and were killed. The survival period in the 12 remaining experiments varied from 2 to 25.5 hours, the average being 9 hours and 37 minutes. The difference in weights of traumatized and non-traumatized extremities varied from 1.19 to 4.85 per cent of the body weight in the different experiments, the average being 3.23 per cent. All of the animals showed an increase in the concentration of the red blood cells. Addition of the 2 types (20 and 40 blows) shows that the average survival period in the 16 experiments in which trauma resulted in shock was 9 hours and 32 minutes and the average difference in weights of the extremities was 3.47 per cent.

The second type of experiment was similar to that just described except that spinal anesthesia was administered before the traumatization and every 30 minutes thereafter unless the animal lived longer than 7 or 8 hours. There were 5 experiments in which the injury consisted of 20 blows with an iron bar. Two of these did not get a marked decline in blood pressure and were killed at 6 and 10 hours, respectively, following the injury. The 3 remaining lived 5 hours and 40 minutes, 8 hours, and 17 hours and 20 min-

utes, respectively, the average being 10 hours and 20 minutes. The average difference in the weights of the injured and non-injured extremities equalled 2.26 per cent of the body weight. The injury in the 5 other experiments consisted of 40 blows with an iron bar. All of these animals died. The average survival period was 6 hours and 17 minutes, the individual times varying from 4 to 11 hours and the average difference in weights of the extremities equalled 3.48 per cent of the body weight. A comparison of these experiments with those in which spinal anesthesia was not given shows very little difference in the 2 groups, the survival period being slightly longer in those without spinal anesthesia.

The third type of experiment was identical with the second except that the spinal anesthesia was not given at regular intervals but was injected whenever the reflexes of the posterior extremities returned. The trauma consisted of 40 blows with an iron bar to break the femur. There were 7 experiments of this type. The blood pressure in 1 experiment remained elevated and the experiment was discontinued after 23 hours. The 6 remaining animals survived from 3 to 21 hours, the average survival period being 8 hours and 3 minutes. The average loss of fluid into the injured part equalled 3.76 per cent of the body weight. An increase in the concentration of the red blood cells was found in most of the experiments. Again, a comparison with the first or control type does not indicate that spinal anesthesia increased the tolerance to trauma.

O'Shaughnessy and Slome noted that the giving of a spinal anesthetic to a cat in shock increased the survival period. These experiments were repeated on 7 dogs anesthetized by chloralose in which shock had been produced by striking the thigh with an iron bar. The average survival period from the time of the trauma was 5 hours and 34 minutes and from the time of the injection of the spinal anesthetic was 2 hours and 33 minutes. The average difference in the weights of the traumatized and non-traumatized extremities equalled 3.93 per cent of the body weight. Again, no evidence that the spinal anesthetic increased the survival time was found.

GROUP III. DOGS: TRAUMA, TRANSFUSION AFTER SHOCK LEVEL, WITH AND WITHOUT SPINAL ANESTHETIC

In experiments under chloralose, Slome and O'Shaughnessy found that a cat in shock as a result of trauma, if treated by the transfusion of blood and by spinal anesthesia, will survive longer than one treated by blood transfusion alone. We have performed 6 such experiments on dogs anesthetized by chloralose. After the blood pressure reached a shock level as a result of striking the thigh 40 blows with an iron bar, the femur being broken, each of the animals was given a transfusion of blood approximately equal in amount to that lost into the injured part and one-half of the animals were given an injection of spinal anesthesia every 30 minutes. The dosage of novocain was the same as that used by Slome and O'Shaughnessy. The animals without spinal anesthesia lived longer on the average than those which were given novocain and the difference in the weights of the traumatized and non-traumatized extremities was somewhat greater in the former group. Four of the 6 animals showed an increase in the concentration of the red blood cells and the other 2 showed no change.

GROUP IV. CROSS-CIRCULATION EXPERIMENTS

The procedure used was similar to that described by O'Shaughnessy and Slome. The carotid artery and external jugular vein of the donor was anastomosed to the femoral artery and femoral vein of the recipient. The *anemic* limb was then prepared, and following this the clips were removed from the vessels listed above, thus establishing the cross circulation. In 2 experiments on animals anesthetized with chloralose, 1 on dogs and 1 on cats, the donors lived only 2 hours following the establishment of the cross circulation and the recipients lived approximately 4 hours. The cause of death was unexplained since trauma was not instituted. In 3 experiments on dogs anesthetized with chloralose, the leg receiving the blood from the donor dog was then traumatized. The blood pressure of the donor fell during the traumatization while that of the recipient remained the same or rose somewhat. The experiments were inconclusive as

regards the length of life, since the donor lived longer than the recipient in 1, the recipient lived longer than the donor in 1, and they died at approximately the same time in another. Both the donor and recipient showed a moderate increase in the concentration of the red blood cells. The traumatized leg of the recipient was heavier in each instance than the opposite leg and in terms of percentage of body weight of the donor this difference was 1.92, 3.94, and 3.07 per cent respectively, in the 3 experiments.

Similar experiments were performed on dogs anesthetized by nembutal. There were 3 experiments, in 1 of which the trauma was repeated. The blood pressure of the donor declined during the traumatization while that of the recipient remained the same or rose. There was a moderate increase in the concentration of the red blood cells in both the donor and recipient. The traumatized animal (recipient) lived longer than the donor in 2 of the experiments and the 2 animals died at approximately the same time in the remaining experiment. The traumatized leg was heavier than the control in each instance and equalled 2.26, 3.2, and 4.8 per cent of the body weight of the donor in the 3 experiments.

In 3 experiments, the procedure consisted of traumatizing a leg which had been amputated except for the obturator, femoral, and sciatic nerves. This leg was supplied with arterial blood from a second animal by the usual technique. Chloralose was used in 2 of the experiments and nembutal in the third. The donor and recipient died at approximately the same time in the 2 experiments in which chloralose was used. The blood loss into the traumatized extremity equalled 3.6 per cent of the weight of the recipient in 1 of these experiments and was insignificant in the other. In the experiment in which nembutal was used, the donor died 2 hours following the traumatization. The blood pressure of the recipient (traumatized animal) was normal 3 hours later and the experiment was terminated.

The cross-circulation experiments were so inconclusive that it was decided that control experiments on the effects of the anemic-limb preparation should be performed.

GROUP V. ANEMIC-LIMB PREPARATIONS

These experiments were performed on dogs and cats, some being anesthetized with chloralose and others with nembutal. Six experiments were carried out on cats anesthetized with chloralose in which the effects of the anemic-limb preparation alone on the blood pressure, reflexes, and length of life were determined. The blood pressure was determined by a cannula in the carotid artery. Five of the 6 animals died in less than 13 hours after the limb had been rendered anemic, or in 13, 9, 6.5, 4, and 3 hours, respectively, an average of 7.1 hours. The blood pressure was usually at a fairly high level until shortly before death, which in several instances was fairly characteristic of respiratory failure due to anesthesia. The sixth or remaining animal was removed from the table after 24 hours in good condition, and in this cat the knee jerks did not disappear. Neither did they disappear in 4 of the 5 remaining animals until shortly before death. In the remaining cat, the knee jerks of the anemic limb disappeared 2 hours after the operation, the animal living 2 hours longer. There was a slight increase in the concentration of the red blood cells in most of the experiments.

Six experiments of the same type were performed on cats in which nembutal was the anesthetic. The length of life after rendering the limb anemic varied from 4 to 13 hours, the average being 8 hours. The length of time that the knee jerks persisted was variable. In 2 animals they did not disappear until a short time before death. A rather marked increase in the concentration of the red blood cells occurred in 3 of the 6 experiments. The high incidence of persistence of reflexes in this and the preceding type of experiment is to be explained at least partially by the fact that trauma was to have been instituted in some of them if the reflexes had disappeared. It is quite possible that the duration of life would have been greater in these cats if the blood pressure had not been determined by cannula which had to be washed out several times during the course of the experiments. In 3 additional experiments on the anemic-limb preparation in which the blood pressure was determined by needle puncture, the survival

periods were 36, 12, and 12 hours, an average of 20 hours. Nembutal was the anesthetic in the first 2 and chloralose in the last. The ligations were below the inferior mesenteric artery.

In animals in which the reflexes disappeared following the creation of the anemic limb, the effects of trauma were studied. Seven experiments were performed on cats, 4 being anesthetized with chloralose. Trauma as usual consisted of 20 blows with an iron bar, the femur being broken. The animals lived from 2 to 5 hours, an average of 4 hours. The difference in the weights of the traumatized and non-traumatized extremities was small, less than .5 per cent of the body weight. A decrease in the concentration of the red blood cells was found in 2 of the 3 experiments in which it was determined. In 3 experiments, with nembutal as the anesthetic, the animals lived 4, 5, and 8 hours, an average of 5.7 hours following the trauma. All showed a moderate increase in the concentration of the red blood cells. The differences in the weights of the traumatized and non-traumatized extremities were very small.

Control experiments without trauma were carried out on dogs. In 1 of the 3 performed under chloralose the aorta was occluded just below the renal arteries, and in 2 below the inferior mesenteric artery. The former animal lived 4 hours and the reflexes disappeared early. The animals with the lower ligations lived 11 and 19 hours, respectively. Reflexes disappeared in 1 and persisted in the other. An increase in the concentration of the red blood cells was found in all. In 3 dogs in which nembutal was used as the anesthetic, the aorta was occluded above the inferior mesenteric in 1 and below it in 2. The reflexes persisted in 1 of the 2 experiments in which the occlusion was below the inferior mesenteric. The animals lived 12, 16, and 16 hours, an average of 14.7 hours. A definite increase in concentration of the red blood cells occurred in 2 of the experiments.

In dogs in which the knee jerks disappeared following the anemic-limb preparation, trauma was applied. In 4 animals anesthetized with chloralose, the aorta was occluded below the inferior mesenteric artery in 3 and above it in 1. Following the disappearance of the reflexes, the leg was traumatized with approximately 40 blows with an iron bar and 15 blows with a hammer, the femur being broken. The animals lived 3, 4, 9, and 17 hours, respectively, an average of 8.2 hours. An increase in the concentration of the red blood cells occurred in 3 of the 4 experiments. The differences in the weights of the traumatized and non-traumatized extremities were 0.87, 2.28, 1.8, and 1.43 per cent of the body weight, the traumatized extremity being heavier in each instance. Four experiments of the same type were done, with nembutal as the anesthetic. The occlusion of the aorta was above the inferior mesenteric artery in 1 and below it in 3, with the animals living 5, 14, 16, and 18 hours, respectively, following the traumatization, an average of 15.8 hours. A rather marked increase in the concentration of the red blood cells occurred in all. The differences in the weights of the traumatized and non-traumatized extremities were .78, .77, 2.15 and .86 per cent of the body weight; the traumatized extremity was always heavier.

These results seem to indicate that the method of O'Shaughnessy and Slome does not render a limb completely anemic as evidenced by the increase in weight associated with trauma. Furthermore, the relatively short survival periods of some of the animals, particularly when chloralose was used as the anesthetic, would seem to question the value of the results of cross-circulation experiments in which the anemic-limb preparation is a necessary part.

EVALUATION OF STUDY—DISCUSSION

The preceding groups of experiments substantiate the views of O'Shaughnessy and Slome on the importance of the nervous factor in the production of shock following trauma to an extremity in only 1 respect, namely, that cats anesthetized by chloralose withstand trauma better if spinal anesthesia has been induced. This was not true in our experience with cats anesthetized with nembutal or with dogs anesthetized with chloralose. These latter findings held when the spinal anesthetic was administered after the shock had been induced as well as in those in which it was given before and at intervals following the trauma.

It is our impression that chloralose is a very dangerous and variable anesthetic. A number of animals were observed to die very suddenly when the blood pressure had been essentially normal a few moments before and the deaths seemed to be due to respiratory failure. This anesthetic was probably chosen by O'Shaughnessy and Slome because the reflexes usually persist after its administration and, in fact, they usually become extremely hyperactive. The cats frequently behave as though they had been given strychnine, jumping violently as a response to noise or touch. It may be that the choice of the anesthetic explains part of the discrepancy in the results of O'Shaughnessy and Slome and those of others. The cats which were anesthetized with nembutal usually maintained their knee jerks and certainly they were more nearly normal than the extremely hyperactive reflexes of the cats which received chloralose. Chloralose has much less effect on the reflexes of dogs.

Cross-circulation experiments of the type described would seem to be an ideal method by which to eliminate the factor of blood and fluid loss in response to trauma, having only the nervous factor influencing the recipient of the trauma. However, the short survival of many of the animals with an anemic-limb preparation (a necessary part of the cross-circulation experiment), particularly if chloralose is used as the anesthetic, would seem to cast doubt on the value of these studies. At any rate, our findings more nearly substantiate those of Bell, Clark and Cuthbertson than those of O'Shaughnessy and Slome. The former authors state, "By means of cross-circulation experiments it was found that trauma applied to a transfused hind limb of the recipient animal caused a marked fall in the blood pressure of the donor, followed by death within 75 minutes. The blood pressure of the recipient was practically unaffected by the injury." We have confirmed the interesting observation of O'Shaughnessy and Slome that the blood pressure of the donor falls during the traumatization while that of the recipient (traumatized animal) usually remains the same or rises slightly. This substantiates their impression that the initial fall in blood pressure in this type of injury is due to the loss of fluid into and from the injured blood vessels. The disagreement is on the question as to why the blood pressure continues to remain depressed. It would seem that O'Shaughnessy and Slome are correct in asking the abandonment of the term, "primary shock," as applied to the early condition that follows injury to an extremity, as this and the later state are parts of one and the same picture.

In regard to the anemic-limb preparation, Slome and O'Shaughnessy state, "It was known that the onset of shock could be prevented by complete occlusion of the arterial supply of the limb prior to trauma. In this case fluid loss cannot occur; we showed that in the presence of such complete 'ischemia,' the limb is also 'anesthetic' and the nervous factor cannot operate." The results of our experiments indicate that the *anemic* limb is not entirely free of a blood supply. The moderate increase in weight with trauma suggests this. As to why most of these animals died, whether or not trauma was instituted and whether or not the knee jerks disappeared, we are unable to state. Some of the deaths were probably due to the anesthetic. It seems likely that the effective blood volume was probably decreased by the accumulation of blood in the posterior part of the body distal to the ligatures on the large blood vessels. If the reasoning of Slome and O'Shaughnessy is correct to the effect that "in the presence of such a complete 'ischemia,' the limb is also 'anesthetic' and the nervous factor cannot operate," some agency other than nervous impulses must be sought to explain the deaths.

Certainly, blood and fluid loss into and near the injured area is the most important initiating factor in the development of shock following trauma to an extremity of the anesthetized animal. After shock is fully developed, many other factors enter into its maintenance and progression. It has been shown (4) that a prolonged low blood pressure as a result of uncomplicated hemorrhage in unanesthetized animals is refractory to transfusion and results fatally. Freeman has shown that prolonged vasoconstriction produces at least part of the ill effects. Some investigators have ignored

the part played by the loss of fluid other than whole blood. Freedlander and Lenhart state, "Rapid hemorrhage produced blood pressure curves similar in contour to those produced by trauma; however, with an equal loss of blood the end-results were more severe following trauma. Further experiments showed that following trauma in addition to the loss of blood there was a considerable local loss of fluid due to edema. Therefore, the added loss of fluid could account for the more severe symptoms following trauma. This confirms the findings of Blalock." Harkins and Harmon have summarized the evidence on the effects of the loss of blood plasma.

Several interesting differences between dogs and cats were evident in these experiments. The reflexes under chloralose have been commented upon. Whereas, the red blood cells became more concentrated in a large percentage of the dogs which were traumatized; a dilution usually occurred in the cat. Cats may survive after a longer period with a marked decline in blood pressure than is true with dogs. The difference in the weights of the traumatized and non-traumatized extremities in percentage of body weight is usually greater in dogs in shock as a result of trauma than in cats. It is to be noted that the difference in the weights of the injured and non-injured extremities in the dogs anesthetized by chloralose was not quite as great as that previously (4) found in dogs in which other anesthetics were used. Elman and Cole state, "We have observed death following the loss of 2.7 per cent of the body weight of a few control cats by simple bleeding from the femoral artery." The figure obtained by Johnson and Blalock in dogs was 5.1 per cent. The difference in the weights of the traumatized and non-traumatized extremities of cats reported in this paper was usually greater than the figure for hemorrhage obtained by Elman and Cole.

It should be emphasized that this paper is concerned only with the results of trauma to an extremity of deeply anesthetized animals. From clinical experience, it seems very likely that nervous impulses do play a part in some instances in the production and maintenance of shock following injuries. The experimental proof of this in anesthetized animals is very questionable. It seems very doubtful if nervous impulses play as important a rôle as is ascribed to them by O'Shaughnessy and Slome. The difficulty if not the impossibility of producing shock by repeated injuries to nerves alone is well known. It is our impression that one should be very hesitant in inducing spinal anesthesia in a patient in shock as a result of trauma. None of the animals, including the cats anesthetized by chloralose, appeared to be benefited by the induction of spinal anesthesia after shock was fully developed. Holt (13) stated recently, "In the same paper O'Shaughnessy and Slome have suggested that the induction of spinal anesthesia in an animal already in a severe state of shock results in a rise in the blood pressure. This has not been our experience. In fact in severe cases of shock it appears as though the induction of spinal anesthesia hastens the fatal result. It has certainly been my experience clinically that it is a most hazardous procedure to give a spinal anesthetic to a patient who is in a state of shock or dehydration without first of all carrying out measures to bolster up the blood-volume."

In concluding, it should be emphasized that the mechanism of the production of all types of shock is not the same and all instances cannot be explained satisfactorily by one theory. This paper deals only with the effects of trauma to an extremity of the anesthetized animal. It has been pointed out that definite conclusions cannot be drawn from these experiments as to the mechanism of the production of shock in man.

SUMMARY

Many experiments were performed on anesthetized animals in which shock was produced by repeated blows to a thigh. The only positive evidence as to the importance of nervous impulses in its genesis was obtained in experiments on cats anesthetized by chloralose in which a preliminary and repeated spinal anesthetic apparently exerted beneficial effects. This was not found in cats anesthetized by nembutal or in dogs anesthetized by chloralose. Neither was it found in cats anesthetized by chloralose in which the novocain was not given until after shock had developed.

Transfusion plus spinal anesthesia was no more effective in treating this type of shock in dogs than transfusion alone. In cross-circulation experiments in which trauma was applied to a transfused hind limb of the recipient animal, no positive evidence as to deleterious effects of nervous impulses was obtained, confirming the findings of Bell, Clark, and Cuthbertson. The local loss of fluid in and near the injured area is the most important factor in the production of shock in anesthetized animals in which an extremity is traumatized. It is not maintained that this is the sole factor in the production and maintenance of this type of shock but that it is the most important one.

It has been emphasized that the mechanism of the production of all types of shock is not the same and all instances of shock cannot be explained satisfactorily by one theory. This paper deals only with the effects of trauma to an extremity of the anesthetized animal.

REFERENCES

1. Bell, J. R., Clark, A. M., and Cuthbertson, D. P. Experimental traumatic shock. J. Physiol., 1938, 92: 361.
2. Blalock, Alfred. Experimental shock. Arch. Surg., 1930, 20: 959.
3. Idem. Acute circulatory failure as exemplified by shock and hemorrhage. Surg., Gynec. & Obst., 1934, 58: 551.
4. Idem. Shock. Further studies with particular reference to the effects of hemorrhage. Arch. Surg., 1934, 29: 837.
5. Cannon, W. B., and Bayliss, W. M. Note on muscle injury in relation to shock. Rep. Shock Com., Med. Research Com., 1919, 26: 19–23.
6. Dale, Sir Henry. Discussion on traumatic shock. Proc. Roy. Soc. Med., 1935, 28: 1494.
7. Edmunds and Gunn. Cushny's Pharmacology and Therapeutics. P. 253. Philadelphia: Lea & Febiger, 1928.
8. Elman, Robert, and Cole, W. H. Loss of blood as a factor in death from acute portal obstruction. Proc. Soc. Exper. Biol. & Med., 1932, 29: 1122.
9. Freedlander, S. O., and Lenhart, C. H. Traumatic shock. Arch. Surg., 1932, 25: 693.
10. Freeman, H. E. The effect of total sympathectomy on the occurrence of shock after hemorrhage. J. Clin. Invest., 1938, 17: 359.
11. Harkins, H. N., and Harmon, P. H. Plasma exudation. Loss of plasma-like fluid in various conditions resembling surgical shock. Ann. Surg., 1937, 106: 1070.
12. Holt, R. L., and Macdonald, A. D. Observations on experimental shock. British M. J., 1934, 1: 1070.
13. Holt, R. L. Discussion on traumatic shock. Proc. Roy. Soc. Med., 1935, 28: 1473.
14. Johnson, G. S., and Blalock, A. Experimental shock. IX. A study of the effects of the loss of whole blood, of blood plasma and of red blood cells. Arch. Surg., 1931, 22: 626.
15. O'Shaughnessy, L., and Slome, D. Etiology of traumatic shock. Brit. J. of Surg., 1935, 22: 589.
16. Parsons, E., and Phemister, D. B. Hemorrhage and shock in traumatized limbs. Surg., Gynec. & Obst., 1930, 51: 196.
17. Simonart, A. Etude experimentale sur la toxémie traumatique et la toxémie des grands brûlures. Arch. internat. de pharmacol., 1930, 37: 269.
18. Slome, D., and O'Shaughnessy, L. The nervous factor in traumatic shock. Brit. J. Surg., 1938, 25: 900.
19. Sollman, Torald. Manual of Pharmacology. p. 754. Philadelphia: W. B. Saunders Company, 1926.
20. Wood, and LaWall. United States Dispensary. 22d ed., p. 1312. New York: J. B. Lippincott Company, 1937.

BENIGN STRICTURES OF THE BILE DUCTS WITH A NEW METHOD OF TREATMENT

GEORGE EWART WILSON, M.B., F.R.C.S., F.A.C.S., Toronto, Ontario

BENIGN strictures of the bile ducts are among the less common causes of obstructive jaundice, but they constitute the most difficult problems in gall-bladder disease which surgeons are called upon to treat, for unless the flow of bile is directed freely into the intestinal tract the patient has nothing to look forward to but a miserable existence ending eventually in death.

CAUSES OF STRICTURES

In addition to the congenital variety, which is fortunately rare, there are 3 causes of benign strictures of the bile ducts: injury to either the common hepatic or common bile duct at the time of the cholecystectomy; ulceration with subsequent cicatrization about a stone in the duct; or inflammation in the ducts quite apart from the presence of a stone.

Injury at a previous operation, however, is by far the most common cause. Walters, at a staff meeting of the Mayo Clinic, reported 51 operations for stricture of the bile ducts and draws attention to the fact that in every instance there had been a previous operation upon the biliary tract, all but 3 having had a cholecystectomy. Lahey, who at the time of his paper on strictures of the common and hepatic ducts had operated upon 37 patients, expresses the same opinion. There are several ways in which the ducts may be injured and these are well exemplified in Lahey's article. The only safeguard, however, is visualization of both the common hepatic and common bile ducts before either the cystic duct or artery is tied, having in mind various abnormalities, especially the presence of a long cystic duct which is adherent to the common hepatic duct for an inch or so before joining with that structure to form the common bile duct. Recently, in operating upon the biliary tract, I found the hepatic artery crossing in front of the entrance of the cystic duct and then continuing on into the hilus on the right side of the common hepatic duct, where for a time it was thought to be the duct; so it behooves the surgeon always to take a second look and be sure.

But, while it is true that the great majority of benign strictures are the result of faulty technique in removing a gall bladder, the surgeon is not always to blame. Aynesworth reports the case of a woman whose gall bladder was removed 2 months after a cholecystostomy and the patient remained well for 7 years. She then returned with all the signs of an obstructed common duct which at operation was found to involve about an inch of the proximal portion of the common bile duct. Certainly in this instance the cholecystectomy cannot have been the cause which must be attributed to cholangitis. There are many instances in the literature of the stricture developing or at least showing itself 2 or 3 years following the removal of the gall bladder. In fact, Judd was strongly of the opinion that an obliterative cholangitis was responsible in a large number of cases. Be this as it may there is one infallible sign that the operator has been at fault, that is the prolonged drainage of bile from the operative wound, a complication which was a marked feature of the case which I am to report.

The history of difficulty in controlling hemorrhage from the cystic artery, as pointed out by Lahey, is also of the greatest significance; and hurried attempts to secure the bleeding vessel without first obtaining a dry field are responsible for the many instances in which the common hepatic duct is injured. The time of the onset of the jaundice depends upon the extent of the injury to the duct, upon the consistency of the bile, whether thick or thin, and whether or not all the bile is being discharged through the abdominal wall;

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

for it is quite possible for jaundice to become manifest in the presence of an external biliary fistula. The jaundice usually comes on, however, in from 3 to 6 months after the operation and, in a typical case, is painless in character and gradual in its onset. But there must be a wide range in the time necessary for the bile duct to become so small that all the bile cannot get through; and it is probably fair to conclude that if a patient, following a cholecystectomy, has had a normal convalescence and has remained well for a period of 2 years, any subsequent disease in the biliary ducts cannot properly be ascribed to the operation. As Carter points out, the inflammatory reaction most likely was there in an insipient stage at the time of the cholecystectomy.

Strictures which are the result of operative trauma, like those occasionally seen following ulceration about a stone, are usually local in character; while those caused by a chronic inflammatory process generally involve a considerable portion of a duct. In contradistinction to this local inflammatory lesion is the condition in which all the extrahepatic ducts are the seat of an obliterative cholangitis, and as this disease is exceedingly rare I am taking this opportunity to report a case which recently came under my observation.

Mr. K. B. H., 42 years of age, while in a mining camp in Northern Ontario in the spring of 1937, suffered an attack of what was described as dysentery which confined him to bed for 3 weeks. Some 4 months later he noticed that his skin was becoming yellow but otherwise he felt quite well; in fact, he exposed his body to the sun to hide the discoloration from his friends. During the early part of October he was in the hospital 1 week for observation and investigation and, except for the jaundice, the findings were largely negative. The liver edge could not be palpated and the stools, while not normal always, gave a positive reaction for bile. There was no elevation of temperature or pulse rate and no leucocytosis. The van den Bergh test on admission showed 52 milligrams per 1000 cubic centimeters of blood and as the jaundice was definitely fading on discharge it was thought that his was a case of infectious jaundice. During the first week in November the patient noticed that the jaundice was getting worse and he was admitted to St. Michael's Hospital on November 19, 1937, under the care of Dr. Harold Armstrong of our staff. At that time he was quite deeply jaundiced, the urine very dark, and the stools clay colored. There was, however, no enlargement of the liver and the gall bladder could not be palpated. Again there was no history of pain and the temperature and pulse were normal. Exploration was decided upon and in preparation he was given calcium chloride and glucose.

At the operation, which was performed on November 24, the gall bladder was found to be normal and free from stones, but the common bile duct was about one quarter its normal size and felt like a fibrous cord. On incising it in a longitudinal direction only about a dram of pale bile came away. The wall was very thick and its lumen would barely admit a No. 4 ureteral catheter; and when the common hepatic and right and left hepatic ducts were examined, they were found to be in a similar condition. An attempt was made to drain the biliary system with a ureteral catheter but the patient went down hill steadily. Two days after the operation he ejected a rusty sputum, and this was followed a few days later by a severe secondary hemorrhage which required a transfusion. Very little bile was ever secreted and the operation site became filled with blood clots. He died of cholemia on December 7.

A somewhat similar case was reported recently by Phillips and Kilgore except that in their patient only the common hepatic and right and left hepatic ducts were involved. But their description of the findings is misleading, as the heading refers to the common bile duct so that all 3 may have been involved. No operation was performed because of the precarious condition of the patient. The diagnosis was made at the autopsy. Like the congenital variety, this is a most distressing type of obstruction and one for which little or nothing can be done.

METHODS OF TREATMENT

Many methods of dealing with a benign stricture of the bile ducts are in vogue but each stricture is an individual problem and the operator must decide upon the best procedure to adopt after a careful examination of the lesion and having in mind his own capabilities. Provided, as is usual, that the gall bladder has been removed and is therefore of no help, an end-to-end suture over a T-tube or some modification of this is best; but it is often not feasible because of the extent of the stricture, since, to be successful, there must be no tension on the suture line. Failing this the W. J. Mayo operation of anastomosing the divided duct to the duodenum is best, although because of the liability to stricture formation in the end-to-end suture, this by some is

considered the operation of choice. Provided the stricture is below the entrance of the cystic duct, this is not a particularly difficult procedure to one accustomed to gall-bladder surgery; but to the inexperienced it may be a hazardous operation, especially as is the case when a long and tedious dissection is necessary before the exact condition of the ducts is demonstrated. But if the stricture extends high up in the common hepatic duct, it may be quite impossible or even highly dangerous, particularly in a fat subject or when dense adhesions prevent the duodenum from being mobilized sufficiently to permit accurate anastomosis without tension. It is to benign strictures of this kind, in which neither end-to-end suture nor some form of direct anastomosis between the dilated duct and the gastro-intestinal tract is feasible, that I wish particularly to direct attention in this paper.

Several methods, many of them very ingenious, have been employed in an attempt to establish a connection with the intestinal tract. One plan is to incise the stricture throughout its length and, after making sure that the distal portion of the duct is open to the duodenum, to connect the two ends with a rubber tube of suitable size and length and to suture the adjacent tissues snugly over it. Some prefer that the tube be passed through the ampulla into the duodenum, while others advise that it should stop short of the bowel. If it is the intention to have the tube remain *in situ* or to remove it once it has served its purpose, it should not pass through the ampulla; for there is abundant evidence as shown by Sandblom, Bergh, and Ivy, that the danger of infection spreading up the duct is increased by any interference with the function of the sphincter of Oddi. And under such circumstances there is danger not only of a biliary fistula but, what is much more important, a duodenal fistula as well. But passing a tube through the ampulla of Vater is by no means the simple procedure which a perusal of the literature would lead one to suppose. It may in fact be quite a difficult feat and, if the inside of the duodenum were examined in every instance, not a few would be found to have entered by a false passage as may be verified by a perusal of autopsy findings. Of course, if the ampulla can once be entered for sure by some form of bougie, dilatation to the requisite size is readily accomplished; but in a small percentage of cases there is always a reasonable doubt about where the instrument has gone.

Leaving a rubber tube in a bile duct has many disadvantages and, as Lahey contends, is at best nothing more than a makeshift. It may pass too quickly before time has been afforded for reconstruction of the channel, and to obviate this difficulty McArthur puts a reverse cuff on the end of the tube. On the other hand, it may remain too long, for it is probably true that if it does not pass it will sooner or later give rise to trouble. Naturally, the more normal the bile flow is in consistency the longer will the symptom free period be, but incrustations both within and without the tube are almost inevitable and they may actually block the flow of bile. Colp, however, states that many tubes which have apparently been in the ducts for almost a year show very little deposit of bile salts, and he is most insistent that the greatest care be exercised in selecting the best and highest grade of rubber and, if possible, a variety that is opaque to the x-rays. Judd removed a calcified tube in one case 4 years and in another 6 years after its insertion, the patient in each instance suffering from a severe attack of cholangitis. But Lahey, in the excellent article already referred to, treated one of the strictures by this method and made reference to removing a tube, for what he does not say, which had functioned well for 7 years and which he replaced by another.

But there are other objections to the indwelling tube; whether its distal end projects into the duodenum or not. It may become displaced upward so as to lie in the hilus of the liver, as in a case recently reported by Robert L. Payne. When used in an end-to-end suture, the tube has been known to become angulated at the suture line with the production of a biliary fistula, and to obviate this, Voelcker advocated bringing the tube out through the duodenum by the Witzel method; but this merely substitutes the danger of a duodenal fistula for the biliary one, although in a reported case the result was most gratifying.

Then again, instead of acting as a channel the tube may actually be obstructing the flow of bile, as shown by the prompt relief sometimes seen following the evacuation of the tube which may even be vomited. There are recorded instances of a tube causing intestinal obstruction and Roeder, apparently in a personal communication to Eliot, refers to a case in which a long tube in a biliary fistula implantation perforated the sigmoid causing a fatal peritonitis 3 months after insertion. Most surgeons then would probably agree with Lahey that this method is at best only a makeshift.

Another way in which these difficult strictures may be treated is by the Wilms-Sullivan method. This consists of inserting a tube of suitable size into the proximal part of the duct and the distal end into the duodenum and then covering the exposed portion of the tube with omentum. Ellsworth Eliot, Jr., whose remarkable contributions to the subject of benign strictures of the bile ducts are of outstanding merit, and from which I have drawn freely in preparing this paper, has with commendable zeal and energy collected 38 cases in which this type of repair was employed. Thirty-five of these are reported in his 1936 article, together with 3 others, those of Brewer, Terrier and Propping which were omitted from his collection in SURGERY, GYNECOLOGY AND OBSTETRICS, published in January, 1918.

An analysis of these cases is most instructive. Of the total, 5 are reported by Wilms and his associate Brandt and there was no mortality, but in none was the elapsed time sufficient to properly appraise the result. Two of the patients developed a duodenal fistula, 1 so severe as to require a jejunostomy and the other required a second operation for its relief. In a third case the operation had to be repeated. Jenckel has had the best results from this method. He has had 10 operations to his credit with only 2 deaths, 1 of which, however, did not occur until 12 years later and from the description death in this instance was undoubtedly caused by a liver ailment. Altogether there were 11 deaths or a mortality rate of approximately 29 per cent.

If Wilms' and Jenckel's cases are omitted, which would give a more accurate cross section of the death rate from this operation, the mortality rate approximates 39 per cent. In many of the reported cases important details are lacking but recurrence of the stricture is common together with cholangitis, biliary and duodenal fistulas, and abscess of the liver. In this connection it is interesting to note, as emphasized recently by Sandblom, Bergh and Ivy, that following any abnormal channel between the biliary and intestinal tract hepatitis and liver abscesses are of frequent occurrence, and, peculiarly enough, they give little clinical evidence of their presence and are discovered only at autopsy. But it is not in the nature of things for surgeons to be eager to report their failures, so there must be a considerable number which are not recorded. It would appear, however, that sufficient evidence has been collected to show that the Wilms-Sullivan operation leaves much to be desired.

Another method by which these difficult strictures can be treated is to allow a biliary fistula to form, wait 3 or 4 months and then cone out this track and implant it into some portion of the gastro-intestinal tract. The operation, however, is by no means a simple one for, unless an adequate blood supply is provided, the fistulous track will die; and even if this difficulty is overcome, undue tension will have the same effect so that it is not to be wondered at if failures are frequent occurrences.

Again we are indebted to Eliot for his collection of 41 cases, the majority of which are from surgeons in this country. In 22 the implantation was into the duodenum, in 18 into the stomach, and 1 into the jejunum. Here, too, some of the reported cases were too recent to evaluate the result, but there were 18 in which death could be attributed to the operation making a mortality rate of about 45 per cent. Hemorrhage, shock, and hepatic insufficiency account for many of the early deaths, but if the patient survives the operation there are many complications which may supervene. Nine of these patients are reported to have developed strictures and in one instance this occurred a second time, so that

in these cases another and obviously much more difficult operation had to be performed in order to relieve the individuals of their distress. Lahey has operated on 14 patients by this method, 7 of which are recorded in Eliot's list, and concludes that in only 2 instances was there permanent benefit, most of the survivors having fared badly because of contraction of the fistulous track. One of his patients, however, was well 15 years after the operation. But Walters, who has performed this operation 9 times, 7 of which are in Eliot's list, expressed the opinion that it continues to be a useful procedure. One of his patients was symptom-free 9 years after the operation.

According to personal communications to Eliot, the German surgeons also were having trouble with the direct method of implantation. Hildebrand in an attempt to obviate the bad results divided the upper jejunum and, after re-establishing the continuity of the intestinal tract, brought the distal end out through the abdominal wall for anastomosis to the opening on the skin of the biliary fistula. His patient died, however, 5 years later with deep jaundice and a subhepatic abscess. Other German surgeons modified this procedure but with no better result. Nevertheless, in spite of the few brilliant results which have been obtained by direct implantation of the fistulous track, it must be obvious to all that any operative measure, which in the hands of experts carries such a high mortality, must be undertaken with a considerable amount of misgiving. Most surgeons would probably agree with the statement of Vincent, as quoted by Eliot, that a partial result which begets cirrhosis is not worth while.

Another way in which these difficult types of stricture have been dealt with is by direct anastomosis of the liver substance to some portion of the intestinal tract, usually the duodenum. This operation is known as hepato-enterostomy. Eliot has succeeded in collecting 11 cases, all from German sources and mostly by personal communication; but as far as I can learn there is no report of a similar procedure having been done in this country. It is performed by puncturing the liver with the actual cautery in an attempt to establish a biliary fistula, and subsequently dissecting this out and implanting it into some portion of the intestinal tract, or the punctured liver may be immediately anastomosed to the intestine. That bile may flow quite freely from a liver fistula is attested to by many authors. I recall a jaundiced patient in whom a copious discharge, which lasted for nearly 4 weeks, followed the incision of a necrotic area in the left lobe of the liver. It had, however, very little effect upon the icturic index and eventually closed leaving the patient no better off than before. Granulation tissue encroaches more and more upon the lumen and though it may be kept open for a while by curetting, the tissue usually wins out in the end. Enderlen's patient, who was alive and well 11 years afterward, is assuredly a brilliant result; but Enderlen also reports a second case in which the same technique was used, following the failure of a previous hepatoduodenostomy, and the patient died about a week postoperatively. At the autopsy the original anastomotic opening was found to be completely obliterated. But in Lameris' patient, who died 8 months after the operation from multiple abscesses of the liver, there were 10 small openings in the liver at the anastomotic site from which bile could be expressed. Undoubtedly there is a considerable variation in the distribution of the large bile ducts within the liver.

Any considerable discharge of bile from the liver in doing a cholecystectomy is unusual, but some years ago I opened up a bile duct fully an eighth of an inch in diameter about 1½ inches from the anterior border of the liver, and so freely did bile flow that it was thought at first to be coming from an injury to one of the main ducts. For 2 weeks the discharge of bile was fairly free after which it gradually ceased and the wound was closed within a month. It would appear then that there is a considerable element of luck in selecting the area of liver to be joined to the bowel. It does not, however, strike one as a feasible way in which the bile may be successfully drained into the intestinal tract, and the fact that it has not been taken up by any surgeon in this country is probably sufficient to indicate that it has little to recommend it.

The new method which I wish to record is in reality a very simple procedure and consists essentially of making a new bile channel out of the wall of the stomach but without opening it. The exposure of the ducts, a tedious, difficult, and dangerous procedure at all times, is made in the ordinary way. If the operator decides that an end-to-end suture is impossible or an anastomosis of the proximal end to the duodenum is not feasible, one proceeds as follows: After isolating the dilated portion of duct which will likely be found high up in the hilus of the liver, and making sure of its identity by aspiration with a hypodermic needle, the operator slits it sufficiently wide to admit a tube about the size of a No. 20 French catheter which is immediately inserted and the opening closed tightly around it by a suture. The tube is then placed upon the anterior surface of the stomach commencing just proximal to the pylorus and buried for a distance of 2 inches in its wall by oversewing with a running stitch of catgut. Omentum is then tucked about the exposed portion of the tube that lies between the bile duct and the stomach after which the free end of the tube is brought out through the upper portion of the abdominal incision, where it is securely fastened by a silkworm stitch and the abdomen closed (Fig. 1).

Our original conception was to withdraw the tube in about 3 months when it was thought a new channel would be well established. It would then be a simple matter to insert an internal urethrotomy knife the requisite distance, cut through the wall and produce an internal fistula; but to our surprise nature, apparently by a process of ulceration, had accomplished this for us. Following this the external opening promptly closed.

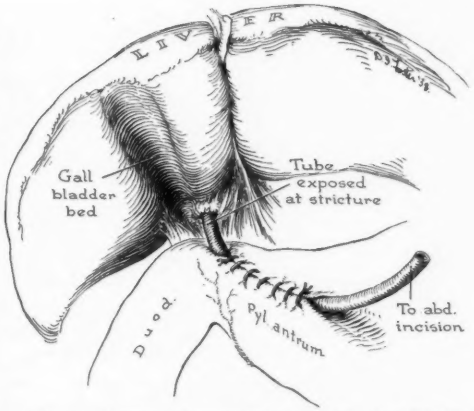


Fig. 1. Diagram showing tube entering the bile duct, bridging the gap to the region of the antrum where it is embedded by the Witzel method and then on to the abdominal incision.

Case 1. Mrs. M., 26 years of age, having suffered repeated attacks of colic with jaundice, was operated upon by another surgeon on September 21, 1932. The gall bladder containing 1 moderately large stone was removed and, although the common bile duct was not dilated and there was no jaundice at the time, the ducts were examined by passing a lead probe through the stump of the cystic duct split to admit the probe. The probe is said to have entered the duodenum and no stones were found. The next day there was a profuse flow of bile mixed with blood from the wound and this was the precursor to a very stormy time. The bile continued to be discharged from the surface and by the middle of October the stools were clay colored. In spite of the external biliary fistula she commenced to get jaundiced about the middle of November and by the end of the month it was very marked. On December 3, 1932, I operated upon her hoping to find a stone, but after a tedious dissection no trace whatever could be found of the common bile duct; and the stump of the common hepatic duct appeared as a grape-like projection in the hilus of the liver. One limb of a T-tube was placed in the duct and the other into the duodenum while the stem together with a Penrose drain was brought out through the abdominal incision. In a few days, although the stools were bile stained, she developed a very severe type of duodenal fistula so that very soon much of the food she consumed together with a large quantity of bile was discharged through the wound and she lost weight quite rapidly. She went through a very trying period but after a couple of months she commenced to pick up and she was discharged on March 3, 1933, with the T-tube still in place. She had no jaundice at this time but there was still a small quantity of duodenal content coming away alongside of the T-tube. She enjoyed tolerable health until August when she began to have frequent attacks of pain and jaundice so the T-tube was removed. No improvement followed and by the end of October the external fistula had closed. On December 14, 1933, she was re-admitted at which time she was deeply jaundiced with clay colored stools and very much underweight. On December 20 I operated on her again and after a most difficult dissection isolated the proximal portion of the duct and performed the operation described. Her convalescence was quiet and uneventful. Bile discharged freely from the tube and the jaundice rapidly cleared. She was discharged on February

11, 1934, with instructions to keep in touch with our outdoor department. In my absence arrangements were made on March 22 to produce an internal fistula but after a few whiffs of ether she vomited up bile and the operation was not proceeded with as it was obvious an internal fistula had already been established. Following this no bile or stomach content came from the abdominal wound and the opening was closed in 2 weeks. She has never had an attack of jaundice since and when seen recently looked in perfect health having gained 40 pounds.

One of the great advantages of the operation herein recorded is that it is a simple procedure and one that may be quickly carried out. Most patients, by the time the ducts have been clearly visualized, are in no condition to undergo any further difficult procedure, hence the advice of some surgeons to permit the formation of a biliary fistula and do a second operation later. Since the stomach is not opened at the time there is no possibility of peritonitis or a dangerous fistula. Obviously, a single case in which the patient has been well for nearly 5 years is not sufficient to permit one to make extravagant claims; and stricture and cholangitis, the bugbears of bile-duct surgery, may yet supervene unless perchance the endothelial cells from the peritoneal coat of the stomach be more effective in producing a protective lining than the epithelium has been in some other types of reconstruction. But complications will probably occur even after most successful reconstructions of the ducts if there is a sufficiently long survival and a proper follow-up is instituted.

CONCLUSIONS

Most benign strictures of the bile ducts follow a cholecystectomy and an unexpected flow of bile from the wound a day or so afterward or a stormy convalescence is very significant.

Diffuse narrowing of the ducts is a rare variety and a case is recorded.

End-to-end suture or direct anastomosis of the duct to the duodenum is the operation of choice when this can be accomplished without tension.

The difficult cases, however, are those in which these methods are impossible and it is with this type that the paper largely deals.

The disadvantages and difficulties of reconstruction over a buried rubber tube are outlined. The Wilms-Sullivan operation and the implantation of the biliary fistula into the gastro-intestinal tract are shown to be unsatisfactory and accompanied by a very high mortality. Direct anastomosis of the liver substance to the bowel is a method which has been used by continental surgeons only and is not to be recommended.

A new method which is simple and safe for dealing with these difficult strictures is recorded and details of a successful case are given.

BIBLIOGRAPHY

1. Aynesworth, K. H. Stricture of the common bile duct. 1935, 27: 562–568.
2. Carter, R. Franklin. Benign fibrous stenosis of the common duct. Am. J. Surg., 1935, 30: 110.
3. Colp, R. Biliary duodenal intubation. Surg., Gynec. & Obst., 1936, 63: 157.
4. Eliot, Ellsworth, Jr. Benign cicatricial strictures of the bile ducts. Ann. Surg., 1936, 104: 668.
5. Judd, E. S. Stricture of common bile duct. Ann. Surg., 1926, 84: 404–410.
6. Lahey, F. H. Strictures of the common and hepatic ducts. Ann. Surg., 1937, 105: 765–790.
7. McArthur, L. L. Repair of the common bile duct. Ann. Surg., 1923, 78: 129–138.
8. Payne, Robert L. Discussion of paper by Drs. Heuer and Lahey. Ann. Surg., 1937, 105: 786.
9. Phillips, J. R., and Kilgore, F. H. Primary inflammatory stricture of the common bile duct. Am. J. Surg., 1935, 27: 545.
10. Roeder, C. A. Ann. Surg., 1930, 91: 144–147.
11. Sandblom, P., Bergh, G. S., and Ivy, A. C. Cholecystoduodenostomy combined with pyloric exclusion. Ann. Surg., 1936, 104: 702–710.
12. Voelcker, F. Beitr. z. klin. Chir., 1911, Vol. 72, p. 581.
13. Walters, W. Strictures of the bile ducts. Results in 51 operative cases. Proc. Staff Meet. Mayo Clin., 1937, 12: 25–30.

CANCER OF THE STOMACH

W. H. OGILVIE, M.Ch., M.D. (Ox.), F.R.C.S. (Eng.), London, England

WE may find cause for satisfaction in the general advance of surgery during the last decade, but upon the subject of cancer of the stomach we can look only with gloom. It is the commonest of all cancers, and though its incidence varies in different countries, it, nevertheless, occupies this unenviable predominance. The operability in cases of patients presenting themselves with symptoms is lower than with any other growth. The operative mortality remains much as it was 30 years ago and is the highest of any major operation. The cure rate among those that survive is the lowest in cancer surgery. Yet no alternative treatment that might relieve us of this depressing and almost hopeless task has appeared on the scene. I have chosen to present this unsatisfactory subject because I consider that in endeavoring to set our house in order we ought to pass by its beautiful chambers, many of them recently renovated and redecorated in the latest style, and turn our attention to the dreary basements. I shall make suggestions as to how we should set about this task, but I shall not present my own figures, which are too few to be impressive and too true to be good. I may, however, illustrate the position today by a simple diagram, constructed from the figures of many surgeons of experience and repute (Fig. 1).

Gastric cancer thus presents a four-fold problem for attack: It is the commonest and least operable of all growths, and its treatment by surgery has the highest death rate and the lowest cure rate. If any of these aspects can be tackled successfully, we shall be doing something to better the present position; and they can all be tackled. We know that the disease is commoner in certain countries, in certain areas in those countries (Fig. 2), and in those areas it is seen most often in men of certain occupations. It should not be beyond the power of statisticians to trace the factors that are responsible for this incidence, or of public health authorities to eliminate them.

The low operability rate is a reflection upon our diagnosis. Many sufferers from cancer of the stomach have no warning beyond an indefinable loss of strength till nearly the whole organ is involved; but on the other hand many of those who arrive, to our chagrin, far too late, have suffered from digestive discomfort for months or even for a year or 2, and have had recourse to diet and alkalis before finally coming to their physician for an overhauling. Should we not write up in neon lights in every restaurant, "Indigestion does not start after 40 in a man who has been able to eat anything till then." Should we not even put a more discreet notice in the office of our medical colleagues, "Gastric ulcer does not present itself for the first time after 40." Both statements are obviously open to exceptions. But if we make it a rule that every case of indigestion, starting in middle life, be immediately investigated to eliminate cancer before any treatment is undertaken, and if we label every gastric ulcer first appearing after 40 as malignant, until unequivocal appearance in the gastroscope, or rapid disappearance of the deformity in the roentgenogram and of occult blood from the feces have shown it to be innocent, we shall immediately bring a large number of patients from the hopeless into the hopeful category. It is, however, with the last two aspects, the high death rate and the low cure rate that we, as surgeons, are particularly concerned.

To discuss mortality implies setting a figure, just as to discuss a golfer's handicap implies fixing bogey for the course. Among good surgeons I would put the hospital death rate between 20 and 30 per cent after operations for cancer of the stomach. I am aware that figures of 10 per cent and under have been recorded, but knowing what I do of the limits of technical skill, I cannot believe that they all refer to the same thing. A few gastric

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

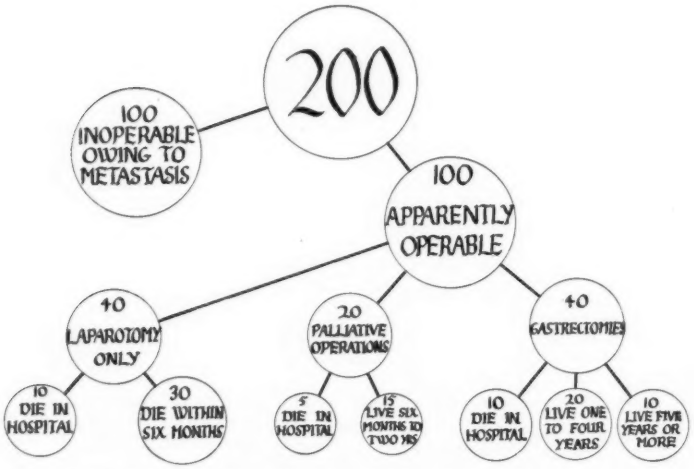

200
100 INOPERABLE OWING TO METASTASIS
100 APPARENTLY OPERABLE
40 LAPAROTOMY ONLY
20 PALLIATIVE OPERATIONS
40 GASTRECTOMIES
10 DIE IN HOSPITAL
30 DIE WITHIN SIX MONTHS
5 DIE IN HOSPITAL
15 LIVE SIX MONTHS TO TWO YRS
10 DIE IN HOSPITAL
20 LIVE ONE TO FOUR YEARS
10 LIVE FIVE YEARS OR MORE

Fig. 1. The fate of 200 cases of cancer of the stomach presenting themselves at hospital.

ulcers slipped in by a lenient pathologist will do wonders for any series.

In the hands of expert surgeons, patients do not die of gastrectomy. Shock has been abolished and hemorrhage does not occur. Speed without haste and neatness without fuss ensure that patients leave the table little the worse for their ordeal. But patients die after gastrectomy because those with cancer of the stomach are old, enfeebled, and liable to die at any time, so that they often succumb while they are in the hospital for investigation or are undergoing palliative treatment. Nevertheless, we must remember that in the operation for cancer of the stomach we are working pretty near the limits of human endurance, and if we are to improve our late results we must push right up to those limits. Whatever of speed, dexterity, and gentleness we have learned from the great masters like Halsted and Moynihan we must put into practice.

To those technical details I would add one further that to my mind is essential, the use of local anesthesia. However good a surgeon's mortality may be, it will be better if he adopt this method. Local anesthesia will make the operation easier for the surgeon, and this leads to neater and quicker work, but it also removes all need for hurry, should extra time be wanted for some refinement. Relaxation is perfect; respiratory movements are slow and shallow; the blood pressure is not raised nor the capillaries dilated; and the viscera preserve their tone and movement and do not prolapse from the wound. It abolishes many of the risks of the postoperative period. The patient is conscious and rational; unlike the subject of spinal anesthesia, he can sit up; he can breathe, move, and drink, so that the likelihood of respiratory, vascular, and embolic complications is greatly diminished. Further he has inhaled no foreign vapor or gas, so that he will not secrete respiratory mucus in excess. These advantages continue over the later stages of recovery; for the solution employed, introduced by Crile for anoci-association, is anesthetic for 4 hours at any rate and diminishes painful sensations for several days, tiding over the patient to the stage of repair. The inhibition of a painful wound is avoided.

I hesitate to describe my methods, knowing that the use of local anesthesia is associated above all with the name of Hans Finsterer, to whom I owe more than I can say. But since I had the opportunity of seeing him do only 2 cases, and used the method 7 years before and 6 years since that time, I cannot say how far my present technique corresponds to his. I can only say that it has proved entirely

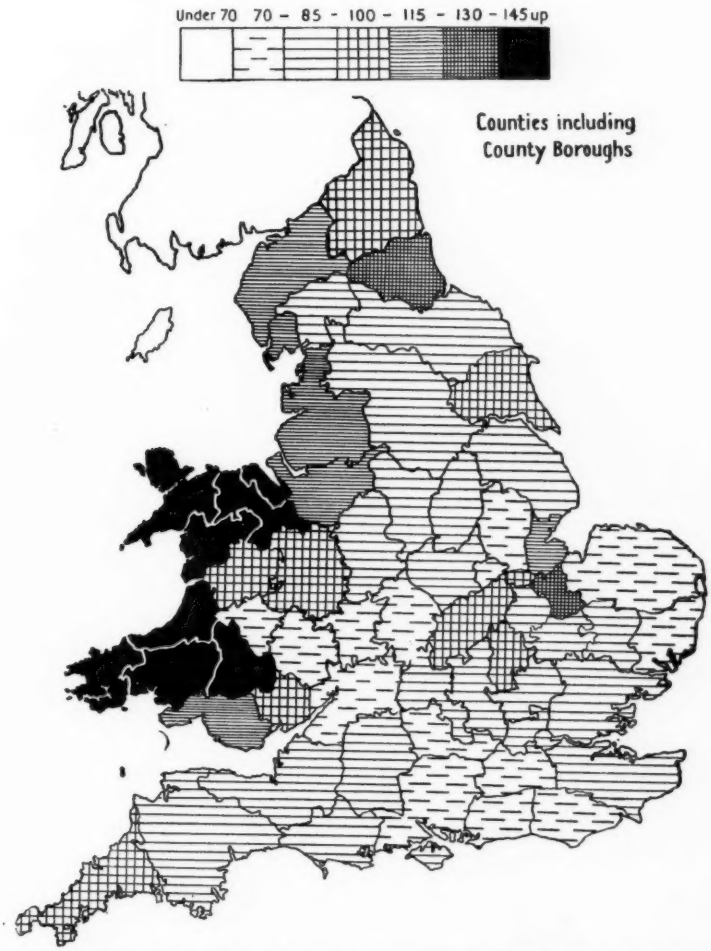


Fig. 2. The regional incidence of cancer of the stomach in the British Isles, as judged from the returns of the Registrar General. (Reproduced by kind permission of the British Empire Cancer Campaign.)

successful in some 250 gastric resections, and that the number in which it has had to be supplemented by gas is only about a dozen.

Premedication is necessary because no normal person can lie still for 1 to 2 hours on a narrow and rigid table unless so prepared. Basal narcotics are unsatisfactory for this purpose, for they make the patient a reflex animal bereft of higher control, and he responds to all stimuli by movement. After many experiments I have adopted the use of omnopon, two-thirds of a grain 1 hour before operation. Two adjuvant drugs should be avoided: atropine, because the thirst it induces makes the patient restless; and hyoscine because, though it quiets some patients, it makes others silly drunk and quite uncontrollable. After the omnopon is given, the patient's ears are plugged with wool and his eyes covered. He is brought to the theater

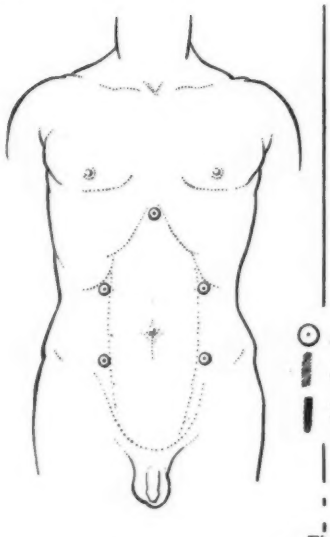
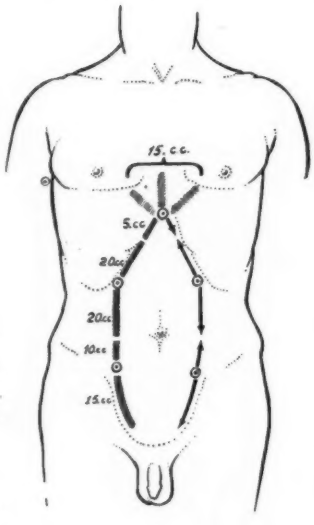


Fig. 3.

Fig. 3. Local anesthesia of the abdominal wall: (1) cutaneous wheal, (2) subcutaneous injections, (3) deep injections.



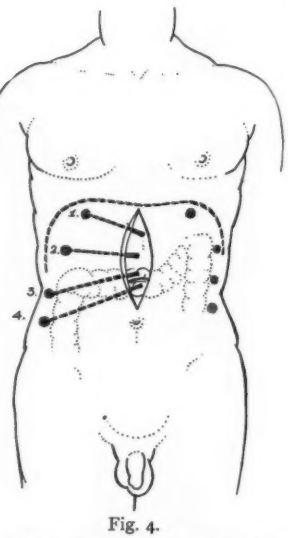


Fig. 4.

Fig. 4. Supplementary injections into the abdominal parietes from within.

some minutes before the surgeon is ready, and encouraged to doze off on the table.

The anesthetic solution is made in two strengths: 1, novocain, one-half per cent; quinine and urea hydrochloride, one-fourth per cent; Ringer's solution to 400 cubic centimeters; 2, novocain, one per cent; quinine and urea hydrochloride, one-fourth per cent; Ringer's solution to 60 cubic centimeters. To each solution 1 drop of adrenalin for every 10 cubic centimeters is added just before use.

I use the Labat 10 cubic centimeter syringe, 2 of which are alternately handed to me, filled by the assistant. Regional block is not tissue infiltration, but measured dosage at certain anatomical points, and with pressure apparatus or self-feeding syringes this ideal is lost sight of. I regard it as important that no local anesthetic be injected into any tissue that is going to be cut or handled, if this can be avoided, so that the whole operation, dissection and subsequent suture, takes place as far as possible in normal tissues. For this reason I have abandoned infiltration of the line of incision.

Injection is done before gown or gloves are put on, 2 temporary sterile towels being put above and below the operative field. This plan enforces a delay of 5 minutes while the surgeon is dressing up, which allows the patient to settle down to sleep, gives the local anesthetic time to take effect, and affords the nurse and assistant an unhurried interval to repaint the abdomen, drape the field, and rehearse every detail of instruments and material before the operation starts.

Fig. 5. Injection of the splanchnic plexus.

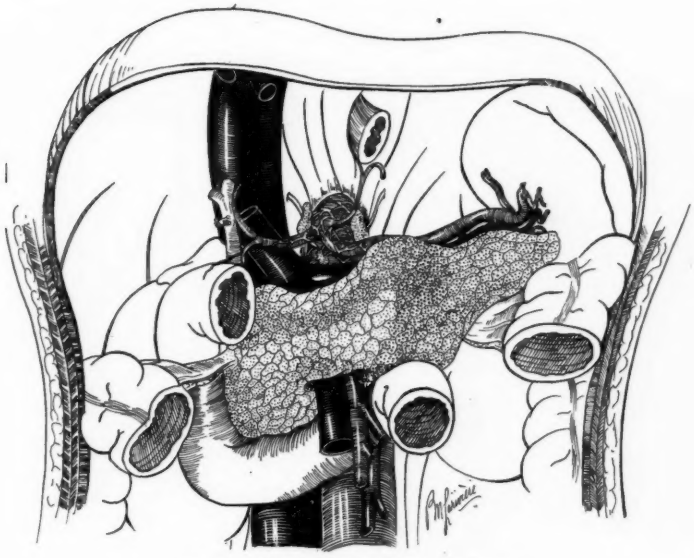


Fig. 6. Relations of the splanchnic plexus.

Five wheals are necessary, 1 just below the xiphisternum, and 2 each side of the outer border of the rectus in the subcostal and interspinous planes (Fig. 3). A very fine needle is used, and after each wheal is made the needle is pushed on into the rectus sheath in several places by sliding the skin, injecting a few cubic centimeters in each, so that sheath and muscle are made insensitive to the larger needle that follows. The whole operation should be painless except for the first 5 pricks.

The next step is to inject the subcutaneous tissues in a fan over the xiphisternum and lower costal cartilages. This area is not insensitized by a rectus sheath block, yet it adjoins the upper end of the incision and may easily be touched by a sharp instrument. An injection of 15 cubic centimeters of one-half per cent solution is used for this. From the same central wheal an injection of 5 cubic centimeters is put into the rectus sheath on each side of the xiphisternum.

A continuous puddle of one-half per cent solution is now laid along the costal margin and outer border of the rectus, to infiltrate the nerves where they lie as single trunks in an aponeurotic compartment. The solution is injected through the 2 lateral wheals into a sheath already anesthetized, and is distributed as evenly as possible, about 5 cubic centimeters to the inch, or 70 cubic centimeters each side. The operator washes up again, putting on his gown and gloves, and returns to find everything ready, and the patient probably asleep.

After the peritoneum has been opened, the wound edges are held up by an assistant, and further injections of one-half per cent solution, or 20 cubic centimeters on each side, are made from within, chiefly into the diaphragmatic peritoneum and the right and left paracolic gutters (Fig. 4). These are areas that have not been anesthetized by the rectus sheath block. A broad and deep retractor is then slipped under the liver and held back by an assistant, while the surgeon places his right hand, palm downward, on the stomach and slips the tips of his fingers down the retractor till they rest on the aorta (Fig. 5). The middle finger identifies the aorta above the celiac axis trunk by the fact that no pancreas intervenes, and then pushes it to the left, increasing the normal space of about half an inch between the aorta and vena cava to 1 inch. The splanchnic injection is made into

Fig. 7. The author's needle for splanchnic anesthesia.

the retroperitoneal tissue in this gap, that is, into the right crus of the diaphragm where it lies on the first lumbar vertebra (Fig. 6). To do this safely it is necessary to have a guarded needle[1] that can be slid along the finger till it rests on the vertebral body without tearing the glove, or injuring the liver or any vessels in the lesser omentum. Sixty cubic centimeters of the 1 per cent solution are injected slowly and diffusely round the splanchnic plexus.

[1]The needle I have designed consists of three parts, the needle itself, a stilette, and a sheath (Fig. 7). A stud on the collar of the needle can engage in 2 slots in the sheath: in the first position the point is hid and the sheath forms a safe blunt instrument of exploration; in the second the point protrudes half an inch and pierces the peritoneum covering the splanchnic plexus.

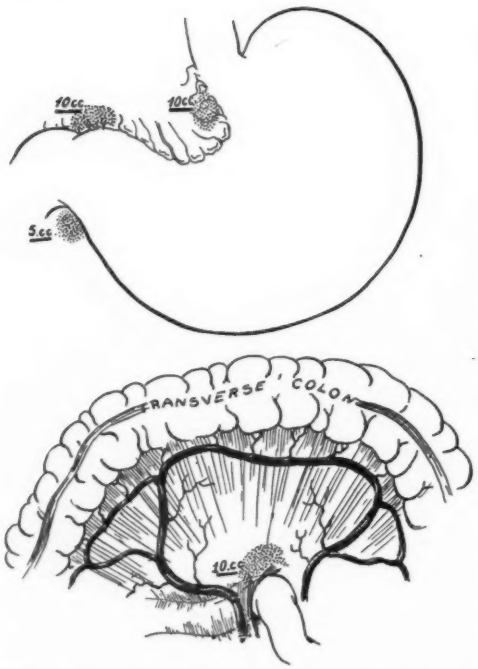


Fig. 8. Mesenteric injections to supplement the splanchnic anesthesia.

I supplement this splanchnic injection by a few further mesenteric injections of one-half per cent solution, a modification I learned from Finsterer (Fig. 8). Ten cubic centimeters are injected into the highest point of the lesser curve, 10 cubic centimeters into its lowest point, 5 cubic centimeters between the duodenum and hepatic flexure, and 10 cubic centimeters into the base of the transverse mesocolon, where the middle colic leaves the superior mesenteric artery. The extra injections make doubly sure that the stomach, duodenum, transverse colon, and jejunum are insensitive; but I believe their chief value is to occupy a few minutes during which the splanchnic injection is taking effect, and to give the surgeon confidence. The combination of splanchnic and mesenteric injections is so harmless and so uniformly successful that I have never felt tempted to go back to splanchnic injections alone.

The present cure rate, judged on the 5 year standard, is from 5 to 10 per cent of all cases operated upon. If the inquiry is limited to cases suitable for gastrectomy, the cures increase from 15 to 17 per cent and if only the patients having had gastrectomies and leaving hospital alive are considered, the rate rises to 20 and 25 per cent. Even so, this figure is one that no surgeon can view without a feeling of profound dissatisfaction. A discussion of the means whereby the cure rate may be improved involves consideration of how the disease spreads and where it recurs.

Cancer spreads by 4 main routes: by direct extension, by the blood stream, by lymphatics, and by dissemination of cells on a free surface. Many cancers of the stomach, when we first see them, are inoperable for 1 of the first 2 reasons, because the growth has invaded neighboring structures too widely for removal, or because the liver contains secondary nodules. But these are usually late cases, and

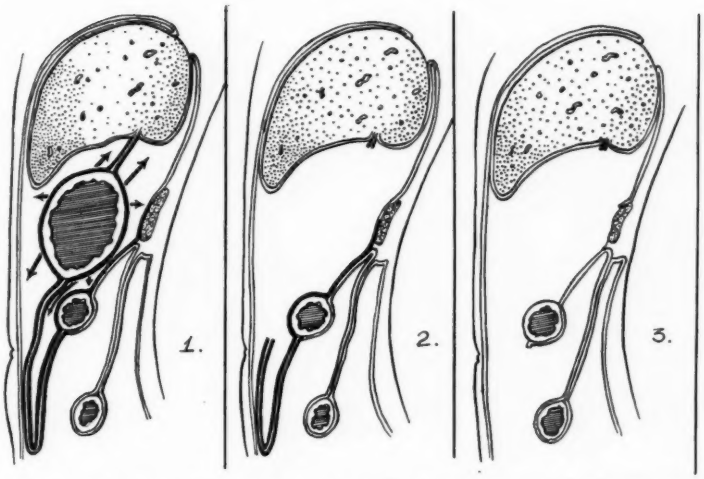


Fig. 9. The peritoneal compartments in relation to cancer spread. 1. Celomic transplantation of gastric cancer; 2, amount of cancer bed removed in standard gastrectomy; 3, amount removed in radical gastrectomy.

it is not often that the otherwise early and operable case is taken out of that category on these grounds.

The sinister features of cancer of the stomach are its wide and early dissemination by lymphatic channels, and its tendency to shed cells that graft themselves on the peritoneum, usually on the omentum or in the pelvis. The cases that seem from their histories to be early and from the skiagrams to be localized but prove on laparotomy to be inoperable, are usually hopeless because of wide dissemination in lymphatic channels or distant peritoneal deposits. Those that recur after an apparently adequate resection do so either in the upper part of the stomach and the glands round the celiac axis, or in distant parts of the celomic cavity. Such recurrences are, of course, the development of extensions that were present but imperceptible at the time of operation, for cancer never recurs. We have here a problem with which we, as surgeons, can rightly concern ourselves while we are waiting for our medical friends to send us earlier cases, and that is the extending of our operation as far as is technically possible to embrace the whole area in which malignant cells are likely to lie in the early and apparently operable cases of gastric cancer.

We cannot, by any means within the compass of practical surgery, remove all seedlings of cancer that may have been cast into the peritoneal cavity. But the earlier free cells, if shed from the anterior surface of the stomach, are likely to lie in that part of the cavity bounded by the anterior abdominal wall in front, and the great omentum behind; and if arising from the posterior surface of the stomach, they will drop into the lesser sac, bounded to a large extent by the omentum and transverse mesocolon (Fig. 9, 1). Removal of the whole great omentum with the stomach, by detaching it from the colon and following this plane down the superior leaf of the transverse mesocolon to the posterior abdominal wall, will remove about 75 per cent of this potential cancer bed (Fig. 9, 3). This step, which on technical grounds simplifies the operation of gastrectomy very considerably for no vessels are cut in this dissociation of embryologically fused structures, is not recommended in gastrectomy for ulcer. The latter should be kept as conservative as possible. In gastrectomy for cancer it is the first essential of a radical operation.

In planning the adequate removal of lymphatic tissues, we have before us that prototype of well planned and successful cancer surgery, the Halsted operation for cancer of

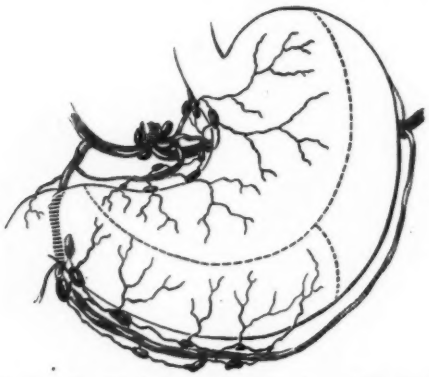


Fig. 10. Simplified schema of the arteries and lymphatics of the stomach.

Fig. 11. Opening the fusion plane between the omentum and transverse colon.

the breast. In this operation, the growth, the organ in which it arises, the lymphatic channels which drain that organ, and the glands into which those channels empty, are removed in one piece. We start in the axilla, stripping the main vessels clear of all areolar tissue, tying all arteries and veins at their junction with the main trunk, leaving axillary vessels and brachial plexus bare, and bringing down the whole mass of fat and glands to be removed with the breast. A radical operation for gastric cancer implies that the vessels are similarly divided at their junction with the parent trunk, and that the whole lymphatic tract that accompanies them is removed with the stomach.

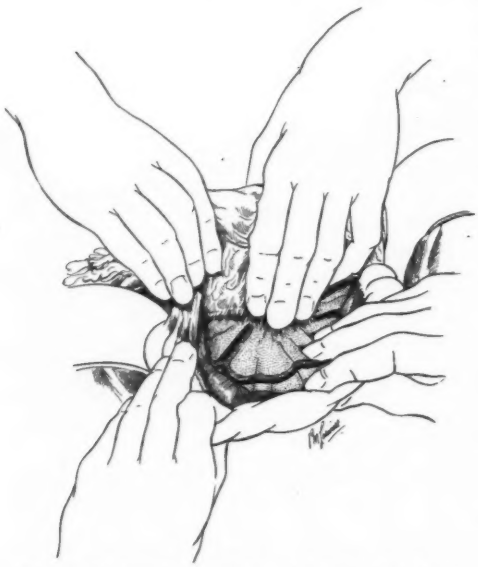


Fig. 12. Freeing the omentum and superior leaf of transverse mesocolon from the colon and mesocolon proper.

Two vessels only are important in this respect, the right gastro-epiploic artery and the left gastric artery (Fig. 10). The left gastro-epiploic is small and far from the cancer area, and the right gastric is in most cases represented by a leash of vessels that supply the duodenum. The right gastro-epiploic arises from the gastroduodenal in the groove between the duodenum and pancreas, and along it are grouped the glands into which the lymphatics of the greater curvature drain. The left gastric is a large artery that springs from the celiac axis just at the upper border of the pancreas, not much above the mid point of the lesser curve of the stomach. After a short course as a trunk it breaks into a number of branches, that spread in a fan to supply the upper border of the stomach from the cardia to the pylorus. The interval between these branches, and between them and the stomach is filled with fat and the lymphatic glands draining the lesser curve. The whole, artery, glands, and fat, is enclosed in a double fold of peritoneum, passing from the posterior abdominal wall to the lesser curve of the stomach, that often includes lobules of pancreas as well.

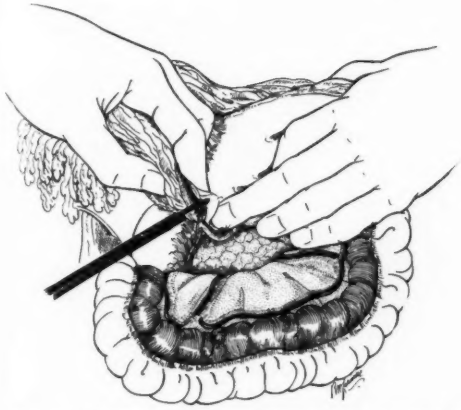


Fig. 13. Ligature of the right gastro-epiploic artery at its origin.

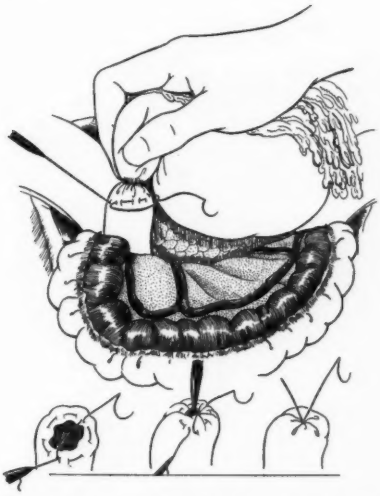


Fig. 14. Author's method of duodenal invagination.

These glands drain the lymphatic plexuses in the submucous and subperitoneal coats of the stomach wall, in which cancer cells are usually found at some considerable distance from the parent growth. The whole stomach could be removed in every case, on the analogy of breast surgery, but total gastrectomy carries a high mortality, one that is never likely to be greatly reduced. It is due to the unsuturable qualities of the esophagus, and could hardly be justified by any improvement in the cure rate that is in sight. Section of the stomach wall 4 inches beyond the palpable edge of the growth is in most cases sufficient to get beyond the extensions in the lymphatic plexuses, and when cancer cells have got beyond this distance they have probably got beyond removal even by the most radical surgery. On the duodenal side

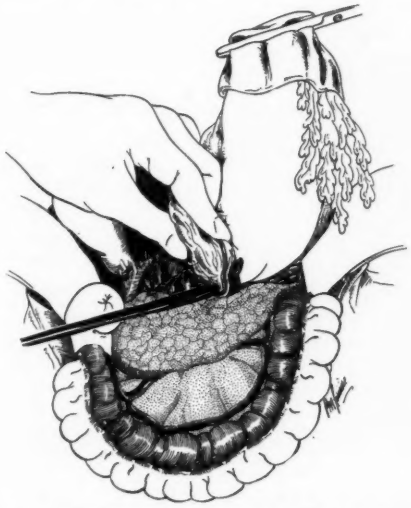


Fig. 15. Exposure of the left gastric artery at its origin from the celiac axis trunk.

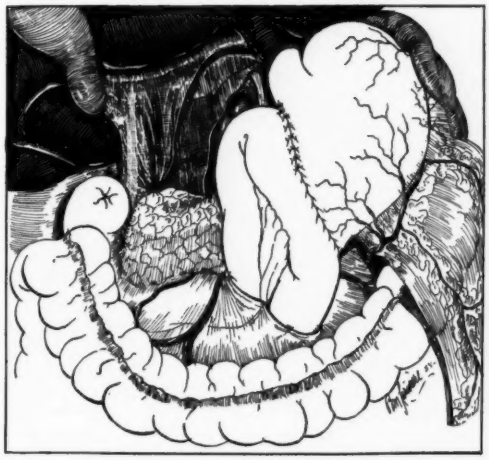


Fig. 16. The operation completed.

the dictum that cancer never spreads beyond the pylorus is as true as most aphorisms; cancer rarely spreads there, but if we examine the duodenum in all our specimens we will find a few in which the wall shows permeation for a short distance. It is, therefore, necessary in an operation that aims at being radical to remove a full inch of duodenal wall with the stomach.

The radical operation for cancer of the stomach may then be outlined briefly as follows: After the abdomen has been opened and the question of operability settled by careful examination and palpation, the assistant holds up the transverse colon to the limit of its mesentery, and the surgeon, extending the great omentum with his left hand, runs a sharp knife along the bloodless fold, now on the stretch, that unites the omentum to the colon (Fig. 11). He carries this dissection right down to the hepatic flexure, following the omentum to its absolute termination on the right, and on the left to within 2 inches of the splenic flexure. With a moist swab he then pushes the omentum upward, when it will separate from the transverse mesocolon, carrying the omental vessels and the posterior peritoneum of the lesser sac with it, until the ridge of the pancreas is reached (Fig. 12). On the right this separation brings the right free margin of the omentum, carrying the main trunk of the gastro-epiploic artery, off the head of the pancreas, where it can be tied as a single trunk (the only ligature that has yet been needed) as it leaves the gastroduodenal artery, a point beyond any recognizable glands of the greater curvature group (Fig. 13). The right gastric vascular bundle is next tied, and the duodenum cleared to 2 inches beyond the pylorus and divided 1 inch beyond it. I crush and ligature the duodenum, burying the stump with a pursestring suture. The method is simple, very safe, and allows more distal division with proper invagination (Fig. 14).

The pyloric end of the stomach is held up, and the lesser omentum, a flimsy structure at this point, is cut with scissors down to the liver. The vascular lymphatic bundle of the left gastric artery is next defined. The lesser sac is seldom the clear space of anatomy books, and congenital fusions between the peritoneum of the posterior gastric wall and that covering the pancreas are common. These are easily separated by scissors and blunt dissection, and the vascular bundle then stands out as a thick fold. The splenic artery can be seen leaving its base to run along the pancreas, and the trunk of the left gastric can be felt in it as a taut cord when the stomach is pulled forward and to the left (Fig. 15.) The artery is cleared, where it leaves the celiac axis, and divided between 2 silk ligatures. With scissors the fatty and glandular tissue is then separated from the aorta and diaphragm up to the esophagus. There should be no bleeding. The stomach is next pulled strongly downward, and the glandular and fatty mass is stripped down from the cardia to a point 2 inches down the lesser curve. The peritoneum is divided with a knife, and the loose tissue pulled down with dissecting forceps. The entrant arteries and emergent veins are ligatured flush with the gastric wall. Finally, the left extremity of the great omentum is divided between ligatures, from the point to which it was separated from the transverse colon to one on the greater curvature just below the lower pole of the spleen.

A mass of tissue is thus prepared for removal that includes the growth, the stomach below a plane passing from the lesser curvature 1½ inches from the cardia to the greater curvature just below the spleen, an inch of duodenum, the whole great omentum and superior surface of the transverse mesocolon, and all the lymph vessels and glands that accompany the left gastric and right gastro-epiploic arteries. The completion of the operation is a matter of technical preference rather than pathological principle. I prefer the valvular retrocolic gastrojejunal anastomosis first described by Lake, and I bring the duodenojejunal flexure above the mesocolon into the lesser sac, fix the highest part of the jejunum close to the diaphragm and close the mesocolic opening round the efferent jejunal loop only (Fig. 16).

This more radical dissection adds a little to the length and difficulty of the operation, but with local anesthesia the first is unimportant and the second moderate. It introduces fresh difficulties in the after-care, for when the lym-

phatic clearance has been adequately performed, so that the aorta and intercrural fibers of the diaphragm are left bare, the splanchnic plexus is also resected in its upper part. I have not observed the cases sufficiently long to have established a regular clinical picture, but all in whom the removal of perigastric tissues has been radical have run a similar course. For the first 24 hours after operation they have been in excellent condition. After that they have shown abdominal distention, constipation, and vomiting of any fluids given by mouth. Flatus was voided, and some subjective relief experienced after enemas, but little fecal matter was passed and the distention increased rather than diminished. With intravenous administration of glucose in water, together with prostigmine and acetyl choline at regular intervals, and ox bile enemas night and morning, the vomiting ceased, and the distention slowly subsided, but it has been nearly a fortnight before the abdomen reached its normal contour.

This operation does not introduce any new principles, but it attempts to carry gastrectomy for cancer to its logical conclusion, and to bring it into line with the operation for cancer of the breast. It should, therefore, add to the number of those who are permanently cured of this dread disease by surgery.

SURGERY FOR ULCERATIVE COLITIS

FRED W. RANKIN, M.D., Sc.D., F.A.C.S., Lexington, Kentucky

THERE are few lesions of the gastro-intestinal tract of a more controversial nature than so called chronic ulcerative colitis. Described first in 1875 by Wilks and Moxon, although a drawing by Cruvelier some thirty to forty years previously accurately depicted the pathology of the lesion, it is a disease of the large bowel characterized pathologically by ulcerations, abscesses, and scars, and clinically by a syndrome associated with diarrhea, blood and pus in the stool, violent febrile reaction, prostration and weakness followed by periods of remission and with a proneness to multiple complications. Many names have been given to this ailment, varying from "idiopathic colitis" to the present day designation, "thrombo-ulcerative colitis." Almost certainly we in America have been discussing a different pathological entity from the one our continental confrères commonly describe as chronic ulcerative colitis, and probably this explains in part the divergent opinions on the etiology, pathology, and particularly the treatment of this not uncommon disease.

ETIOLOGY

No phase of chronic ulcerative colitis is more debated than its etiology. Many organisms have been suggested as causative factors. Deficiency states, as primary or secondary factors, are urged by some observers, and by and large there is scant unanimity of opinion regarding either the mechanism or the productive agents. That there are many types of ulcerative colitis, including tuberculous and amebic colitis, is general knowledge; but the pathological entity, usually referred to as chronic ulcerative colitis, is distinct from these.

The comprehensive, painstaking, and decisive work of Bargen, I feel, distinctly established the fact that a type of streptococcus produces 75 to 80 per cent of the cases of ulcerative colitis. This type he terms, "thrombo-ulcerative colitis" to designate its inception and pathology. The other 20 to 25 per cent of cases he points out, includes those in which there is an element of deficiency; some cases of allergy, a group of chronic bacillary dysentery cases, and that group in which the etiology is indeterminable. Bargen's researches which have been buttressed by application to clinical cases with undeniably advantageous end-results in a large percentage of the group, have been, I believe, the most helpful factors in the modern management of this lamentable lesion.

DIAGNOSIS

The diagnosis of a typical case of thrombo-ulcerative colitis depends chiefly on a combination of the evidences of pathology revealed by roentgenogram and sigmoidoscopy. The findings by sigmoidoscopy are variable but from the experience of many trained proctologists, a characteristic picture of the appearance of the bowel during the active stages and remissions of the disease has been outlined which is constant and trustworthy. Since the progression in the bowel is essentially from rectum to cecum in the vast majority of cases, and its tendency is to appear most characteristically in its active stages in the lower segment of the gastro-intestinal tract easily available to proctoscopy, the early and late appearances of the lesion can be accurately established.

Buie's description of the mucous membrane of the bowel during the period of activity appears to me entirely adequate. He divides this period into four stages: The first is represented by a hyperemia usually most marked in the lower rectum and anal canal, and which fades into the normal mucosa above; the second is but an advancement of the first type and manifests itself as an edema and thickening of the mucous membrane which bleeds on slight trauma; the third is represented by miliary abscesses in the mucosa which are not

Presented before the Clinical Congress of the American College of Surgeons, New York, October 20, 1938.

identified as discreet follicles but are diffusely scattered throughout the whole area and average in size about 1 millimeter in diameter. They are immediately below the superficial layer of the mucous membrane. In the fourth stage, these abscesses rupture and leave ulcers which appear as yellow spots scattered over the wall of the bowel, and which bleed on being wiped with a swab.

The radiological evidences of the chronic stage are constant and marked by narrowing, shortening, hyperirritability, loss of haustration, and signs of destruction of the mucous membrane. Variations in the destruction of the mucous membrane are marked in the different stages of the disease and depend unquestionably upon the extent of bowel involvement, but the signs are too characteristic to be confused with other types of colitis. These laboratory evidences coupled with the clinical picture which is characteristic of thrombo-ulcerative colitis, assist in differentiating this type of colitis from other organic inflammatory lesions of the large bowel.

The clinical course of this chronic infectious disease of the colon is a characteristic one with an acute onset of many bloody stools likewise containing pus and mucus, the number of which sometimes ranges as high as 30 to 40 a day. Septic fever, anemia, and other evidences of infection exhaust and dehydrate the individual rapidly. This picture, along with sigmoidoscopic and roentgenographic evidence, easily and accurately establishes the diagnosis.

INDICATIONS FOR SURGERY

Medical management of chronic ulcerative colitis, which consists of a dietary regimen, administration of vitamin C, elimination of focal infections, and the use of vaccines and serum, is effectual in the majority of these cases to some degree. Intractability to medical treatment with a resulting damage of considerable extent to the colon, from which follows its loss of function and under which conditions the colon becomes filled with pus and detritus and is a source of absorption, is the principal indication for surgery.

Indeed, surgery for chronic ulcerative colitis as for duodenal ulcer is indicated only for the complications which occur in 15 per cent of the cases. These complications, save only for hemorrhage and perforation, occur mostly in the chronic, intractable stages of the disease and fall readily into several classifications: (1) perforation, abscess formation, and hemorrhage usually occurring during the acute stages; (2) polyposis; (3) cancer developing on polyposis (this occurs in a definite percentage of cases, about 2.5 per cent); (4) visceral degenerative changes; (5) unique complications such as erythemia nodosum, pyodermia gangrenosa, liver abscess, gastrojejunocolic fistula, etc.; (6) evidences of focal infection, the lead-pipe colon filled with pus furnishing the source, as in arthritis; and (7) rectal complications such as stricture, fissure, peri-anal abscess, etc.

These complications, depending upon their distribution, the extension of the disease, and the acuteness or chronicity of the disease in each individual case, are indications for surgery of various types. The distribution is of particular importance because in 80 per cent of chronic ulcerative colitis cases as diagnosed by x-ray, the involvement of the large bowel is beyond the rectosigmoid juncture. In a series of 352 cases studied by Bargen, Brown, and myself, roentgenography showed that the entire colon was invaded in 211 cases, 59.9 per cent; the lesion extended from the anus to the hepatic flexure in 240, 68.1 per cent; and from the anus to the splenic flexure in 69 cases; the rectum and sigmoid alone being involved in 26 cases.

This distribution is compatible with the data of other observers. Collins remarked that approximately 93 per cent of chronic ulcerative colitis is universal and only 7 per cent regional or segmental. In our experience, regional or segmental ulcerative colitis does occur, but very infrequently.

TYPES OF OPERATION

The operative procedures usually employed are: (1) colostomy; (2) ileostomy; (3) segmental resection by exteriorization; (4) subtotal colectomy following ileosigmoidostomy; and (5) subtotal or total colectomy following ileostomy.

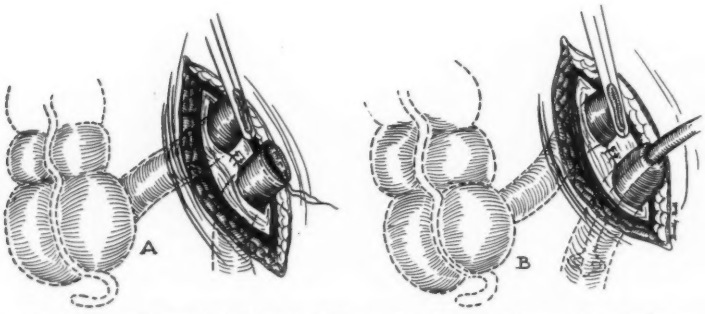


Fig. 1. The split muscle incision has been made mid-way between the anterior superior spine of the ilium and the umbilicus; the ileum picked up 12 or 14 centimeters from the ileocecal valve, the blood supply ligated, and the ileum divided between clamps. The clamp is left on the cecal end of the ileum and a pezzar catheter put in the proximal loop for immediate drainage. The two ends of the ileum are separated by the full thickness of the abdominal wall for about one-half inch.

Colostomy. Colostomy is of relatively small use in most cases of chronic complicated ulcerative colitis. First, the disease generally involves the entire colon; second, if one makes a colostomy above the infected area in a regional ulcerative colitis, the disease has a tendency to leap over the colostomy and involve the segment above. How this is accomplished, whether by direct continuity of tissue, by the lymphatics, or through blood stream invasion, is not definitely established, but it has occurred not once but several times in my observation.

Jones, of Cleveland, has suggested that possibly a colostomy with complete division of the bowel and mesentery might be a useful operation for colitis situated in the left half of the colon. So far as I know, this procedure has not been tried out in any large series of cases and its utility remains to be proven.

Ileostomy. Ileostomy has 2 indications: first, in chronic ulcerative colitis either as the first stage of a graded procedure for colectomy, or as a permanent drainage operation; and second, in the acute fulminating stage. In this latter condition, I question if ileostomy or any other operation is of much use; but if surgery is indicated for hemorrhagic, fulminating infection or the acute toxemia which goes with a violent case of ulcerative colitis, by-passing of the fecal current by ileostomy is the method of choice. It should not be performed in uncomplicated cases and except in a very small selected group of the acute variety. As an instance of how futile ileostomy is as an agent in the acute group, two hemorrhagic cases in my service serve as examples. In both cases ileostomy was helpless to stop the hemorrhage and a fatal outcome resulted. Again, I would urge that once an ileostomy has been established, its closure is distinctly questionable. I have closed one case which remained symptom-free for 2 years when an exacerbation necessitated the performance of a second ileostomy. Twice I have closed ileostomies with exacerbations, resulting during the hospital period, with a fatal outcome in each case.

In 1932 with Bargen and Brown, I reviewed the histories of 82 patients upon whom ileostomy had been performed for acute fulminating ulcerative colitis and progressive complicated ulcerative colitis with evidences of absorption. Following operation in this group there was a hospital mortality in 26 cases, or 31.7 per cent. This immense mortality and the unsatisfactory end-result of ileostomy, plus the more satisfactory results of a better managed medical regimen, influenced us to abandon it more and more each year except as one part of multiple stage procedures.

The technique of ileostomy which I have found useful, with certain modifications, was described in SURGERY, GYNECOLOGY AND OBSTETRICS, August, 1932. I utilized the original technique as a preliminary step to total abla-

tion of the colon in 6 cases, 3 of chronic ulcerative colitis and 3 of polyposis.

The single-barrelled ileostomy which was utilized in that series may be criticized on one point, namely, that a stricture developing along the course of the colon in a blind loop of bowel filled with pus, prevents drainage. Recently I have modified this technique somewhat by bringing out both ends of the bowel, dividing it, leaving the clamp on the cecal end, and thrusting a pezzar catheter immediately into the proximal loop for drainage. The procedure is as follows: A split muscle incision is made at a point mid-way between the umbilicus and the anterior superior spine of the ilium on the right side. The ileum is picked up 12 to 14 centimeters from the ileocecal valve, the blood supply of this portion is ligated, and the bowel is severed between clamps, with a cautery. Instead of dropping the cecal end back as in the original technique, the clamp is left on the cecal end, a purse-string suture is placed around the ileal end, and a pezzar catheter is inserted. The two ends of the bowel are separated by the full thickness of the abdominal wall. The clamp is left on the cecal end for 48 hours or longer, but the immediate drainage of the ileostomy is advantageous.

The mobilization of the ileostomy from the abdominal wall in the second stage of the procedure is a little more difficult than when the cecal end is turned in and the bowel dropped back into the peritoneal cavity. Conditions in each individual case will determine which particular type of ileostomy is more desirable.

Ileostomy is always accompanied by great loss of body fluids and a concurrent decline in body weight. There is marked disturbance in mineral metabolism, loss of chlorides in the blood plasma, and a reduction of the serum calcium because of rapid and excessive loss of fluids. In addition, it is much more difficult to care for an ileostomy than a colostomy, but a satisfactory ileostomy bag which fits closely around the opening, keeping the discharge away from the skin has been adequate in our hands. The apparatus is made of non-metal and has a ring with a flange around it which fits a tight rubber dam through which a hole is made to fit the ileostomy so that the soft dental rubber sheeting of the dam is the only part touching the skin. Proper dietary habits will be of great assistance, and after a period of 3 to 4 months the ileum will assume in part the function of the colon, becoming larger and hypertrophied, and the patient will begin to gain weight and strength.

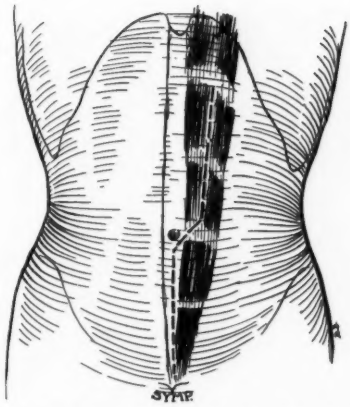


Fig. 2. A long incision in the median line below the umbilicus and advancing upward splitting the muscle fibers of the left rectus muscle beyond that point as high as necessary, is the most useful incision. Regardless of whether a partial or total colectomy is to be done, the mobilization should be made from right to left and this incision allows handling of the entire colon most readily.

Colectomy. Before a colectomy, subtotal or total, is undertaken, pre-operative rehabilitation and decompression should be instituted with the most meticulous care. Adequate hydration by repeated small transfusions, intravenous administration of 5 per cent glucose in normal saline, plus a high caloric diet, are advantageous. Occasionally colonic irrigations may be of help, although frequently they are useless. Lead and opium pills 48 hours prior to operation are advantageous. These efforts increase the general resistance as well as supplement the advantageous effects of self-immunization, and thereby increase the margin of safety.

Removal of part of the colon by exteriorization or by a resection and immediate anastomosis has a limited field of usefulness. Actually, I question if either of these procedures is practical for chronic ulcerative colitis even

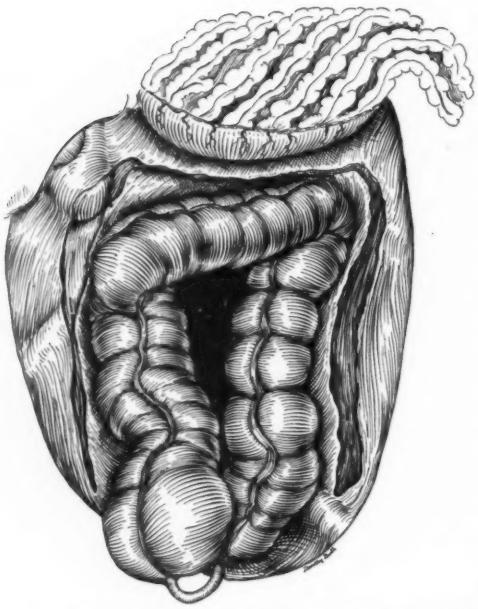


Fig. 3. To illustrate mobilization of the colon on the right side and preservation of the omentum. Ample peritoneum is deliberately saved to cover all raw surfaces. Widespread dissection is not essential as in dealing with malignancy.

of the segmental variety. On the other hand, subtotal colectomy with ileosigmoidostomy or ileocolostomy, where the disease is limited to the right side of the colon and transverse segment, is distinctly a satisfactory procedure in that small group of cases in which the pathological process is so isolated. Subtotal colectomy following ileosigmoidostomy, whereby the entire colon down to the rectosigmoid juncture, is sacrificed for definite indications, is a useful operation and is utilizable in that group of cases in which for one reason or another it is not practical to do a third stage and removal of the rectal stump.

This operation presents no great technical difficulty since there does not have to be a widespread removal of the mesentery as for malignancy, and in addition it is not only more simple, but desirable to save the omentum, another condition different from that dealt with in malignancy. The operation is usually carried out through a long left rectus incision, the lower part of which is a midline one from the umbilicus to the symphysis. The upper margin of the incision is extended as high as is necessary to mobilize the splenic flexure. The mobilization is usually made from right to left and freeing the cecum is sometimes difficult because of the type of ileostomy which has been made. The John Young Brown type of ileostomy is a loop variety of operation and the cecal end of the ileum is opened on the abdominal wall. This has to be mobilized, inverted, and dropped back and the mobilization of the cecum continued from that point.

There are two difficulties which one must keep in mind throughout the whole procedure of mobilization and they are the likelihood of encountering chronic pericolonic abscesses which rupture easily into the peritoneal cavity or, owing to the friability of the wall of the colon, may open into its lumen; and second, the friability of the mesentery which is shortened and thickened, and in consequence, hemorrhage by retraction of the vessels into this fat may become a problem. The mobilization is begun after the ileum is freed and by rotating the cecum mesially and dividing the peritoneal leaflet at its fusion with the parietal peritoneum. The blood vessels are clamped and divided as they appear and the dissection is carried upward toward the hepatic flexure in the same manner as though one were dealing with cancer, except for the sacrifice of the mesentery. The two main structures to be identified are the right ureter and the retroperitoneal portion of the duodenum. The vessels having been ligated and divided as they appear, it is best to peritonealize the raw surfaces after the dissection has progressed to the hepatic flexure, thus completing the right half of the operation entirely before proceeding to the transverse segment. By drawing the omentum upward, one is able to separate it easily from the transverse segment, ligate the blood vessels in this portion, peritonealize the raw surfaces, and move over to the splenic flexure with little or no difficulty. The latter is difficult to mobilize since the attachments are short and when they are supplemented by additional inflammatory bands, the difficulty is increased. The spleno-

colic ligament is divided, the vessels to the segment are clamped off easily, and the mobilization of the descending colon and sigmoid proceeds. The left parietal peritoneal leaflet is divided similarly, the colon is rotated mesially, the surgeon working toward the pelvis. When one has freed the sigmoid down close to the rectosigmoid juncture, preserving if possible the superior hemorrhoidal vessels, it is necessary to locate a point at which the bowel will be divided. If a long piece of sigmoid is left intraperitoneal, it will be necessary to complete the operation as a combined abdominoperineal resection. If, however, one divides the bowel close to the rectosigmoid juncture and makes a new pelvic floor, posterior removal can be done later with less risk.

In dividing the bowel at whatever level, experience has taught me that it should be grasped with a soft rubber, right angle clamp and cut off with a cautery rather than to utilize a crushing clamp which will cut through the bowel wall, leaving the severed end wide open and spreading contamination. I think it wiser merely to sew over the end of the bowel rather than to try to invert it, for inversion of this thickened, friable piece of intestine is usually impossible. The end is wrapped in iodiform gauze and this is brought out of the lower incision, after being wrapped in rubber tissue, as a drain.

The third stage of the operation is either a combined abdominoperineal removal of the rectum similar to that done for cancer, or a posterior resection by Mummery's technique, depending upon where the division has been made and where the blood supply has been ligated. After this stage there is an evident change in the ileostomy; its irritability, and not infrequently the tendency to diarrhea become noticeably improved. Frequently the stools are diminished in number and the function of the large bowel taken on more equably. For this reason it seems to me that subtotal colectomy which has been preceded by ileostomy, should uniformly be followed by removal of the rectum, unless contra-indicated.

MORTALITY FOLLOWING RESECTION

The hospital death rate following total or subtotal colectomy for definite indications in properly selected cases is consonant with the mortality in other types of surgery of the colon for major organic lesions. The main indications for colectomy are: (1) congenital adenomatosis; and (2) refractory or complicated ulcerative colitis. It is quite apparent on survey of the scant literature available that when resection for chronic ulcerative colitis is indicated, the mortality figures are quite satisfactory.

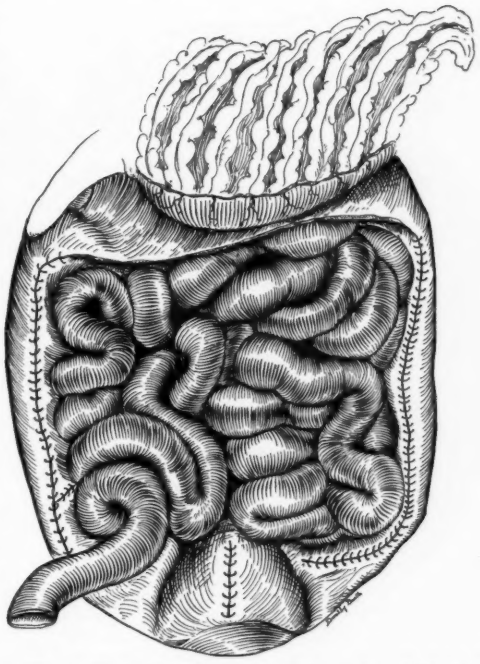


Fig. 4. Illustrating the completed operation of subtotal colectomy following ileostomy. The peritonealization is satisfactory and the rectal stump dropped down retroperitoneally after ligation of the inferior mesenteric vessels. This type of operation can be followed by posterior resection for removal of the rectal stump. If more sigmoidal stump is left, a combined abdominoperineal operation is necessary.

In my own series of 12 colectomies, 7 total and 5 subtotal, the operation was performed for chronic ulcerative colitis 5 times and for adenomatosis 7 times. There was 1 death in this series and it was in a case of adenomatosis; no mortality occurred in the ulcerative colitis group. Cave has recently reported 2 total and 4 subtotal colectomies for chronic

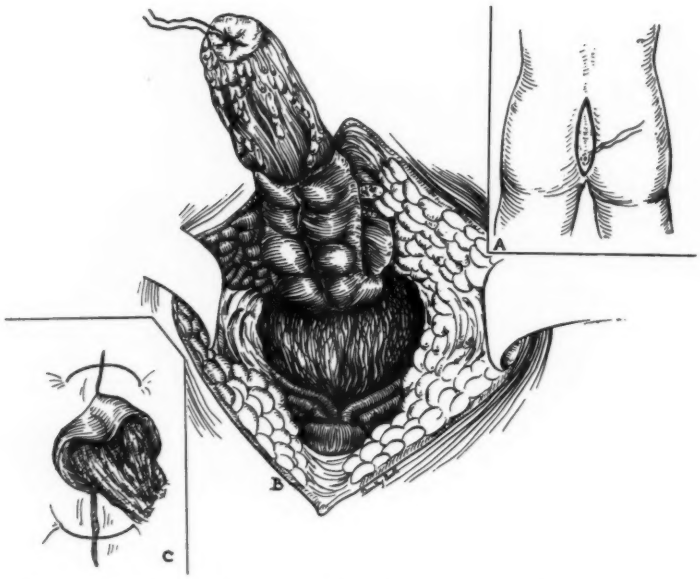


Fig. 5. Illustrating resection of the rectal stump extraperitoneally after the method of Mummery.

ulcerative colitis with no deaths, and Cattell in a personal communication informs me that he has done 16 total and 6 subtotal colectomies for ulcerative colitis with a single death. These are small groups, to be sure, upon which to reckon statistics, but no very large series of colectomies having been published, they indicate that this formidable procedure of ablation of part or all of the large bowel may be carried out under proper circumstances with a reasonable casualty list.

These cases give the appearance of being extremely bad risks because of dehydration, desiccation, and generally exhausted condition due to absorption. On the other hand, the long time during which self-immunization has taken place is an advantage to them against infection, and adequate preliminary preparatory treatment consisting of repeated transfusions and daily administration of large amounts of 5 per cent glucose in saline, raises their physiological equilibrium to a level safe for extensive surgical maneuvers.

The loss of the colon for whatever reason is not attended with serious disturbances of physiology; and when the ileum has assumed in part the function of the large bowel, and the disturbances in blood chemistry and mineral metabolism, which are temporarily upset, have been balanced and weight and strength have improved, many of these individuals return to a useful status.

While it is clear that surgery is indicated only under rare circumstances in chronic ulcerative colitis, the indications are definite that the mortality is reasonable and cure by removal of the extensively diseased bowel is effected under these circumstances in which less radical measures are inadequate.

CONCLUSIONS

1. Surgery in ulcerative colitis is indicated only for complications. These complications occur, first, as rectal or perirectal lesions, or second, usually affect the entire colon from rectosigmoid to cecum. The removal of part or all of the large bowel for chronic ulcerative colitis is definitely desirable when the colon has lost its function and becomes a focus of absorption.

2. Surgery in the acute, fulminating or hemorrhagic forms of ulcerative colitis has few, if any, advantages. In this type of condition, ileostomy which completely by-passes the fecal current may be done under local anesthesia and occasionally appears to accomplish something.

3. Operations for colectomy, total or subtotal, should be carried out in multiple stages. Multiple stage operations increase the margin of safety enormously and sufficient time after performance of ileostomy should be allowed to elapse before resection is undertaken, to replace fluid loss, balance the blood chemistry, and increase body weight and strength.

4. Mortality statistics, following colectomy, parallel statistics for surgery of other major lesions of the colon.

5. The treatment of chronic ulcerative colitis is predominantly medical and no operation should be attempted until all other efforts have proved futile. But when surgery is undertaken, it should be only after adequate and prolonged pre-operative preparation and rehabilitation.

BIBLIOGRAPHY

1. Bargen, J. A. Personal communication.
2. Buie, L. A. Chronic ulcerative colitis. J. Am. M. Ass., 1926, 87:1271–1274.
3. Cattell, R. B. Personal communication.
4. Cave, Henry W. The surgical treatment of intractable chronic ulcerative colitis. Ann. Surg., 1938, 107:806.
5. Rankin, F. W. Colectomy for adenomatosis and pseudopolyposis: A report of five additional cases. Ann. Surg., 1935, 102:707–723.
6. Rankin, F. W., Bargen, J. A., and Brown, P. W. Indications for and technique of ileostomy in chronic ulcerative colitis. Surg., Gynec. & Obst., 1932, 55: 196–202.

REGIONAL ILEITIS

BURRILL B. CROHN, M.D., New York, New York

IT IS just about 6 years since the publication of a paper (4) on the clinical and pathological description of a disease entity, styled regional or terminal ileitis. This is a chronic, non-specific, granulomatous, inflammatory process occupying for the most part the terminal segment of the ileum, and characterized by diarrhea, fever, obstructive phenomena, and often by fistulous tracts, a disease which lends itself favorably to surgical operation. While making no stated claim to priority, we did feel that although non-specific granulomas of the alimentary tract had previously been noted by several observers (17, 18, 25), the clear-cut clinical picture, the roentgenographic appearance, the course and surgical treatment had never been intelligently portrayed, nor had the clinical condition received proper recognition.

Confirmation by current literature of the symptom complex followed within a few months (2, 11, 16) and still continues. Many of these authors confirmed in full the detailed features as we portrayed them; some have cast doubt on the disease as a clear-cut entity. Intelligent criticism and supplementary observations of great interest and importance have received attention. On the whole, the subject has attracted the surgical fraternity into whose hands most of the cases either fall, or will fall eventually; and it is from them, with their biopsy *in vivo*, that the most helpful ideas and the most pertinent suggestions have emanated.

To a large extent the original conception stands; nothing has been subtracted, but considerable has been added. It had been observed (1) that the disease might, on occasion, occupy other than just the terminal ileum; and that the upper ileum and even the jejunum might be affected independently of, or in conjunction with, the more consistently involved terminal segment of the ileum. The iron-clad rule of non-involvement of the cecum and colon in true regional ileitis was soon broken down (3, 5), a fact to which we again acceded, adding the concept, exceptional though it be, of a combined ileitis and colitis. New variations of the original fistulous tracts have been observed and confirmed.

The surgical approach to the solution of the problem has been a field of debate, the partisans of radical resection opposing the antagonistic upholders of short-circuiting palliative measures. The suggestion has been made that the disease is a medical problem entirely and that surgery is superfluous.

Although the time elapsed is short, as time is measured in the world of science, nevertheless, the opportunity is propitious for a restatement of views as judged from a broader concept and an ever increasing personal experience, with due acknowledgment of the opinions and statements of other competent observers.

This report is based upon 110 personally observed patients, 73 of whom have received confirmation by operation. Practically all of the remainder have been examined repeatedly and where feasible, an adequate follow-up has been established and maintained. One hundred and ten cases seen in 6 to 8 years give an idea of the frequency and distribution of this singular disease. Its incidence is almost as great as that of ulcerative colitis, perhaps in the proportion of 1 case of ileitis to every 2 cases of colitis. Neither disease is rare. If alertness and the ability to recognize and interpret clinical symptoms be maintained, the cases will be encountered frequently in all classes of the population.

The point has been made in the literature that the disease appears to have its greatest incidence in the Hebrew race, if not exclusively so. This probably arises from the fact that the earlier confirmatory reports originated from the eastern seaboard, from such cities as Boston, New York, and Philadelphia, or from cities like San Francisco and Chicago with relatively large or proportionately large Jew-

From the Medical Service of the Mt. Sinai Hospital.
Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

ish urban populations. The rural districts have yet to be heard from. My own experience, and the explicit statements regarding nationality in many of the published articles deny the purely racial distribution of the disease either here or abroad. Sweden, South Africa, Holland, Canada, England, and Oklahoma offer instances of the disease in gentiles. With a better acquaintance and a more widespread recognition of the symptomatology, it is my unquestionable impression that the disease will be proved to have neither real racial predilection nor eventually, any preference for color. I have personally observed no case in the negro nor in the Porto Rican population of this cosmopolitan city.

The distribution of the sexes is not exactly even as is usually stated. There seems to be a definite preference for the male, the ratio being 66 males to 44 females, a proportion of 3 males to every 2 females.

The disease remains one of youth showing a definite predilection for the third and fourth decades of life. The youngest patient I have ever seen was 15 years old, the oldest, 58 years of age. The distribution of regional or terminal ileitis with regard to age, as I have found it, is as follows: first decade, none seen; second decade, 10 cases; third decade, 48 cases; fourth decade, 21 cases; fifth decade, 11 cases; sixth decade, 2 cases. More cases are noted between the ages of 20 and 30 years than in all the other decades combined. The average age of the illness, when seen, is 27.8 years. Many of the older patients have histories of such long duration that the origin of the diarrhea is easily dated in the previous decade or decades of life. Yet we must concede the fact that occasionally one does recognize a case *ab initio* in later years. A physician must be loathe, however, to diagnose ileitis in older persons without excluding the commoner diseases of middle life, particularly cancer.

Three times my opinion has been asked regarding the possible rôle of trauma in initiating ileitis or in aggravating present symptoms. On two occasions, automobile injuries, and on another, violent effort were impugned as causative agencies. In the 2 instances of automobile accidents, mild in themselves, no connection could logically be entertained between the slight trauma and a subsequent operation for chronic regional ileitis. In the third instance, hemorrhage into a pre-existing ileitis was claimed as the result of strenuous effort while engaged in an industrial pursuit. Here, some case for an exaggeration of pre-existing symptoms may possibly be made. To my mind it is unlikely trauma bears greater relationship to ileitis than to appendicitis.

CAUSATIVE AGENCIES

An actual etiological agency as the cause of ileitis has not been determined. We seem no nearer to the solving of this problem of the etiology of ileitis than we are to the similar puzzle of the creative factor in a case of ulcerative colitis. The latter disease has engaged close attention for many more years with extensive bacteriological research and animal experimentation without 1 acceptable solution. Both are regarded as non-specific diseases in which no single agent, bacterial or virus, can be successfully implicated.

The appendix has been accused by some (12), but its non-involvement in the pathological process in all but the most exceptional circumstances would seem to exclude it as an incriminating factor. In at least 33 per cent of our cases the appendix had been removed at a previous exploratory operation without affecting or inhibiting the course of the ileitis, nor did the appendix show any pathological changes characteristic of the disease.

Lymphatic block at the ileocecal junction with its maze of rich lymphatics has been accused of originating the disease (21), a type of lipin absorption from the lacteals being the provoking agent in a mononuclear cell type of infiltration. Experimental reproduction of lymphedema in this segment by injecting bismuth into the lymphatics has been adduced in support of this view. This hypothetical conjecture has no support in fact. The occasional recurrence of the disease process at higher levels of the ileum and the jejunum after previous resection of the terminal segments about the ileocecal angle speak loudly against a purely lymphatic block and in favor of a persisting residual infective agent.

I have seen the disease 3 times in siblings. The 2 earlier instances were reported in a pre-

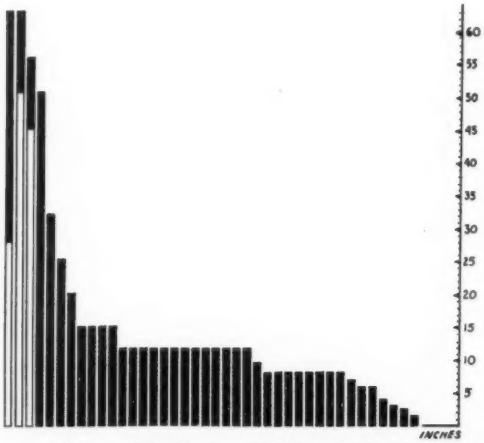


Chart 1. Distribution of ileitis and jejunitis.

viously published paper (6); the more recent instance is that of 2 brothers simultaneously affected by a rather acute process. This surely suggests a common infecting agent, probably bacterial, rather than a mere familial or tissue tendency to the disease. In none of these cases, nor in any other of the operative material, have I ever been able to recover a dysentery organism from either the stool or culture of the resected specimens. Moderately high agglutinations in the patients' serums have been observed occasionally; 1:320 Hiss was seen in 1 case. But the significance of agglutination reactions against dysentery organisms has been questioned recently as specific evidence for the existence of bacillary dysentery, unless supported by the actual recovery and growth of offending bacterias. The reaction is too general and too nonspecific to be of any great significance.

The corroborative evidence offered by Felsen (9) to the incrimination of bacillary dysentery is not convincing but suggestive. The terminal ileum may be involved in severe, universal colitis caused by dysentery, as it is in the non-specific type, in 24 per cent; but the involvement of the ileum alone without participation of the colon is nowhere described in standard textbooks on pathology, nor will pathologists of repute accept such a conception. Felsen's epidemiological and clinical observations, regarding the persistence of ileitis in a few survivors of a true epidemic of bacillary dysentery in Jersey City and elsewhere, is interesting but not convincing, because neither he nor others were able to recover a culture of the organisms in resected specimens.

The microscopic appearance of mononuclear cells in whorls with occasional giant cell inclusions suggest tubercle. The histological similarity to Boeck's sarcoid, as noted by Snapper (22), places both diseases as well as any other similar granulomatous process in the class of pseudotuberculosis. The disease is definitely not caused by the Koch bacillus.

PATHOLOGY

The pathological characteristics of the disease, as originally described, remain essentially identical with our original conception and require but few additional observations. The main brunt of the disease falls upon the terminal segments of the ileum beginning abruptly at the ileocecal valve and advancing upward along the intestine for a variable distance. The vast majority of the cases involve from 2 to 12 inches of the terminal segment of the ileum, but cases have been observed in which as many as 36 to 50 inches have been noted to be continuously affected. In 6 patients the whole of the lower and upper ileum was affected and in 2 at least the jejunum was probably similarly involved. In 1 case seen at autopsy, the small intestine, including even the duodenum, was affected by a continuous inflammatory granulomatous process.

The extent of the involvement is usually announced by the presence of enlarged, succulent, mesenteric lymph nodes adjoining the mesenteric attachment of the intestine. These signal nodes appear paralleling the involved areas, and disappear when the unaffected or skipped-clear area is palpated. The nodes are never calcified nor do they often break down; they constitute an excellent guide to the exploring surgeon in determining the extent of the lesion. The presence of these guiding inflammatory nodes suggests the possibility that so called mesenteric lymphadenitis, as seen particularly in children, is none other than acute ileitis with minimal mucosal lesions and maximal lymphadenopathy. In the light of our increasing experience with ileitis, the concept

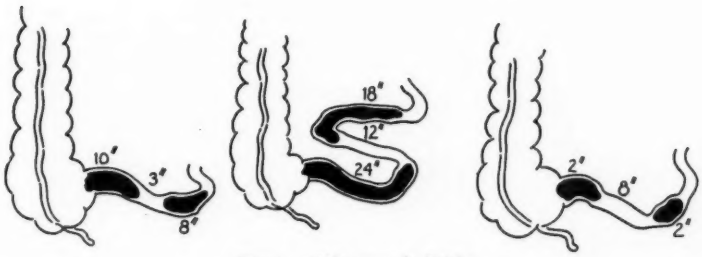


Chart 2. Skip areas in ileitis.

of an independent disease such as mesenteric lymphadenitis, distinct and apart from ileitis, will bear more careful study. The transition of acute lymphadenitis to chronic ileitis has never been observed but is a reasonable potentiality.

Skip areas. The inflammatory process in the ileum is not always continuous, the pathological unity often being broken by one or more skip areas. These areas range from 2 to 12 inches, or as seen in 1 case, as many as 18 inches. They are of the greatest significance at the time of operation, for failure to note the higher skip areas means insufficient resection and accounts for the not inconsiderable percentage of recurrences.

Occasionally, though not often, it is found that the terminal ileum as well as some segments of the colon are similarly involved as observed in 8 cases. More often the cecum and ascending colon are affected in a continuous manner with the terminal ileum. At other times skip areas are seen in the colon, so that the process may appear, for example, in the terminal ileum, ascending colon, mid-transverse colon, or occasionally even in the sigmoid, with these various areas being separated by wide segments of unaffected mucosa. Fortunately for the original clear-cut description of regional ileitis, these combined cases of ileocolitis are few in number, for they represent very difficult problems in surgical judgment. When clinically observed over long periods of time, the colon involvement will often regress with only the diseased ileum remaining for resection. The converse, however, is often true.

Occasionally, the terminal ileum and colon are void of disease but the process is seen involving a limited portion high in the ileum or even in the jejunum. These sections may be only a few inches wide in extent, or may involve more widespread areas with predominant lymphadenopathy. Resections at these points are more difficult and short-circuiting operations usually insufficient. While fistulization rarely takes place from sole involvement of these higher sectors of the jejunum and ileum, Dr. A. A. Berg noted 1 such instance: a fistula originated in a diseased loop of the jejunum and ended in the sigmoid.

SYMPTOMATOLOGY

The onset of the disease is occasionally acute, as seen in 11 cases, but ordinarily the history is one of a chronic illness progressing insidiously. At first there are only occasional bouts of discomfort or diarrhea; later these are followed by continuous intestinal frequency, fever and pain. Sixty-two patients had a history dating from 1 to 5 years; 15 patients, 5 to 10 years; 8 patients, more than 15 years of almost uninterrupted illness. During this prolonged period of non-recognition, various diagnoses were maintained: usually nervous diarrhea with a psychoneurotic background, at times food allergy, and undulant fever with peculiar intestinal changes was noted (24).

The appearance of the mass in the lower, right quadrant or across the lower abdomen is a later manifestation and betokens the spread of the disease into the mesentery; or the formation of sinuous, fistulous tracts may occur; and again there may be agglutination of variously affected coils of the involved small intestine. Not infrequently the mass represents a localized, low-grade, inflammatory peritonitis due to a walled-off slow per-

foration of the ileum, or to the breaking down of infected lymph nodes. The mass may resemble an appendiceal abscess, a urachal cyst, a diverticulitis with perforation, or possibly a secondary intestinal tuberculosis.

Obstructive symptoms do not appear as frequently as hitherto believed. In only 10 cases was intestinal obstruction a predominant phenomenon, which was always partial and incomplete and associated with borborygmi, gurgling, and the palpation of the distended intestinal loops. An inflammatory mass with a long chronic history and signs of obstruction, when occurring in a young person, is highly suggestive of ileitis.

FISTULAS

The outstanding characteristic of this pathological process is its tendency to form fistulous tracts; it is by these tracts that the disease is known. These fistulous tracts are many and diverse; they travel wide distances and appear at unexpected exits. They seem to be chemical or lytic in action, and this is created possibly by the solvent action of seeping intestinal juices containing activated digestive enzymes. They are seldom highly infectious and cause only a low-grade, inflammatory abscess before perforating to the exterior. The following fistulas are recognized:

Internal fistulas, 11 cases. These originate in the terminal ileum but end in some segment of the colon, usually the cecum or the sigmoid. The ubiquitous and redundant sigmoid is frequently drawn up to the right, lower quadrant and attached to the inflammatory mass by an intercommunicating fistulous path; or the fistula may seek the transverse colon for its exit, or the rectum, the urinary bladder, vagina, or some contiguous and adherent loop of the ileum or the jejunum.

External fistulas, 12 cases. These fistulous tracts, again originating in a porous ileum, usually seek the anterior abdominal wall and follow the scar of a previous laparotomy. In fact, I recall no instance of an external fistula to the anterior abdominal wall except in cases in which a previous operation had predisposed the tissue to such a process.

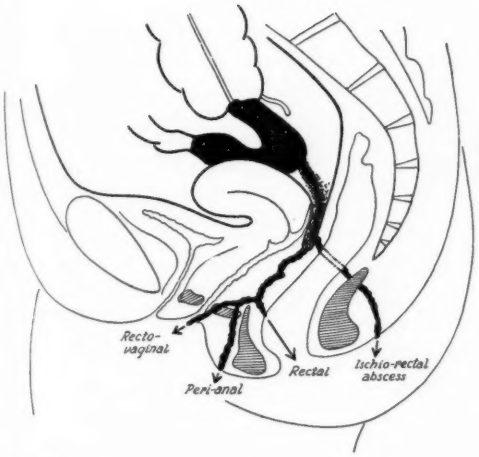
Fistulous tracts to the inguinal, lateral abdominal walls and to the right lumbar regions occur without antecedent operative measures and are apparently of a spontaneous nature. The most interesting are those in the lumbar gutter where they may be observed to form plural openings in a straight vertical line (23, 7), emitting thin intestinal content.

Peri-anal, rectal, and rectovaginal fistulas (8), *20 cases.* These latter fistulas are the most common type of fistulization present in ileitis and deserve the most careful consideration. The methods of formation may be various. Most of the fistulas-in-ano occur as the result of infection in the rectal crypts of Morgagni by transported, contaminated, fecal material. This explanation probably answers for the large majority of simple peri-anal fistulas.

But some of the fistulous tracts have a far more circuitous course. The diseased, heavy, and soggy terminal loop of the ileum lies usually on the pelvic floor near the pouch of Douglas, ascending at an acute angle to enter the ileocecal junction. Infectious pus and material escaping from the porous terminal loop of the ileum seep downward, infecting the pelvic peritoneum and retroperitoneal fat, and burrow through the pelvic fascia by a fistulous tract which tends downward. This tract may make its exit into the rectum above the sphincters; or, piercing the sling-like attachments of the levator ani to the sphincters, may exit at the peri-anal margins. If the infectious fistula pierces the fibers of the levator ani laterally, the ischiorectal fossa is contaminated, and the abscess thus formed will make its exit as a pararectal fistula. In the female, the fistulous tracts may traverse the rectovaginal septum and make its exit in the perineum, the vagina, the rectum, or as a rectovaginal fistula.[1]

The course of these long fistulous tracts is very difficult to follow. Lipiodol injections made from below are usually lost in a pool of radio-opaque material somewhere in the pelvis, the exact location of which defies analysis. On occasion we (8) have noted a streak of barium pointing sharply downward from the terminal ileum as seen during roentgenographic studies. At the same time or in the same case a lipiodol injection of a peri-anal fistula will point sharply upward to the same

[1] See Cunningham's Anatomy, page 1419.



JHB

Fig. 1. Diagram showing the course of fistulous tracts from diseased ileum to various points on the perineum.

direction and location. While the direct path and continuity has not been unequivocally demonstrated, this explanation is offered as a reasonable and plausible analysis of the various chemical and anatomical factors involved.

The clinical significance of these peri-anal and rectal fistulas has not received sufficient recognition. They frequently precede anywhere from 1 to 14 years the onset of active diarrhea and abdominal pain, constituting the one prodromal symptom of regional ileitis.

In 1 instance a patient was admitted to the surgical services of the hospital for routine hemorrhoidectomy. A simple fistula-in-ano complicated the hemorrhoids. An alert interne, taking a routine history, discovered a story of mild diarrhea to which the patient himself had paid no attention. A gastro-intestinal roentgenographic study exposed the presence of a terminal ileitis. Such an instance might be multiplied many times, if it were recognized by internists and surgeons that fistula-in-ano is so often a precursor of regional ileitis before the onset of active abdominal symptoms. Perhaps there is some pathological, bacteriological, or chemicolytic affinity between fistula-in-ano and regional ileitis, since the same infectious process invades different but analagously susceptible regions of the intestinal tract.

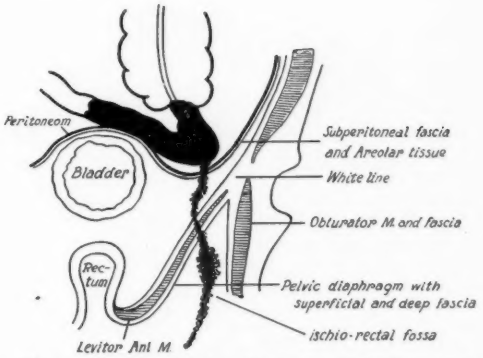


Fig. 2. Diagram showing the course of fistulous tract from diseased ileum via the ischiorectal fossa to the perineum.

COURSE AND PROGNOSIS

The acute cases of ileitis whether explored by operation or not, will, if not interfered with, run a variable course. Of the 11 patients seen with acute ileitis, many were explored but not otherwise resected; 3 have undergone a recession of their symptoms, suggesting that a spontaneous cure is possible occasionally. The experience of Koster (14) is similar to our own. He explored 6 patients with acute ileitis without further interference. They seem to have done well up to the time of the publication of his paper, though the duration of the follow-up is not specifically stated. However, considering the chronicity of the typical ileitis case, it is quite certain that the last word has not yet been said in these many instances (20). The 8 remaining patients did poorly; 6 of them were operated upon eventually.

The chronic case of ileitis that remains unoperated upon may come to grief. Two such cases came to autopsy. In both of them death was due to pelvic peritonitis with diffuse intra-abdominal suppuration and abscess formation. In the second case, a pelvic abscess perforated the urinary tract so that feces were passed through the urethra.

The usual chronic ileitis case runs a long course over a space of years. It is characterized by marasmus and nutritional disturbances due to protracted diarrhea and anemia, and ends eventually in the formation of multiple fistulas, or with the late picture of a

partial intestinal obstruction, when operative indications can be denied no longer. Spontaneous healing in a case of chronic regional ileitis has not been observed.

DIFFERENTIAL DIAGNOSIS

It can no longer be said that ileitis is a disease which defies accurate, pre-operative diagnosis. The clinical course is so typical; the negative sigmoidoscopy, and the barium enema which rules out the existence of a right-sided colitis, force one's attention to the small intestine as the most probable origin of the inflammatory diarrhea.

Roentgenographically, both the barium enema and the barium meal are highly efficient measures for the detection of the characteristic string-sign (13, 10), or of an equally suggestive fuzziness and filling defect in the terminal or lower segments of the ileum. Very rarely will the roentgenogram fail. In 1 case only, a highly suggestive history led to the diagnosis of ileitis. A most competent radiologist declared the x-ray plates negative. Nevertheless, laparotomy disclosed a typical but early terminal ileitis. This mistake in the interpretation of x-ray studies is so rare as to constitute the exception that proves the rule.

In the absence of the typical roentgenogram, other causes of diarrhea must be considered and ruled out, such as thyrogenic diarrhea with its greatly heightened basal metabolism rate, the gastrogenic diarrhea of achylia gastrica, or of a carcinoma anywhere in the stomach or in the alimentary tract. Diarrhea due to food allergy or purely nervous or emotional diarrhea require due consideration in evaluating intestinal hypermotility. Hence it is essential to get a complete personal history of each patient.

The greatest difficulty arises in differentiating cases of non-tropical sprue from instances of high regional enteritis. The roentgenographic picture in sprue is not characteristic or constant and consists of puddling and delays in higher loops of the ileum and the jejunum without constant anatomical deformities. The stools of patients with sprue are characteristically frothy and abundant and do not, as in ileitis, show a constant positive test for occult blood. Anemia is most severe and often of a hyperchromic type, the glossitis typical and the signs of an avitaminosis more likely to be present.

In enteritis, or high ileitis, the process usually is only an extension upward of a similar granuloma of the terminal ileum. The roentgenographic defect is structural and constant and the stools are more purulent and more often contain gross or occult blood.

If the physician be given a characteristic or a suggestive roentgenogram of an ileal defect, knows the age of the patient and the protracted clinical course, there will be need for consideration of only very few differentiating conditions. Hodgkin's disease and multiple sarcomatosis of the small intestine are extremely rare in comparison with ileitis. Both of these diseases occupy by predilection higher sites in the small intestine than the terminal ileum. They both may give rise to profuse, gross hemorrhages in the intestinal tract, a symptom which is unusual in ileitis.

In one case all differentiating signs failed. In a patient with a typical case history suggestive of all the classical signs of ileitis, except the fistulas, but with the characteristic roentgenogram, resection was done. The pathological examination surprisingly disclosed the terminal ileum occupied by 4 small infiltrating argentophillic carcinoid tumors.

In the past, most cases of ileitis were erroneously called primary intestinal tuberculosis. If such a condition exists as tuberculosis of the intestinal tract, independent of tuberculosis elsewhere as in the lungs, glands, pleura, joints, etc., then it is so rare that it fails to warrant the confusion it has originated. In a complete survey of all the postmortem and surgical, pathological material in Mt. Sinai Hospital, representing a vast accumulation over the last 15 years, only 4 cases of primary intestinal tuberculosis survived a critical analysis. In 2 of these patients the ileum was the site of a mucosal lesion with typical miliary tubercles and the tubercle bacilli were found in the intestinal lesions and nowhere else in the body. These 2 cases cannot be denied and might have been confused with ileitis. All other cases of intestinal tuberculosis were traceable and were secondary to a primary focus elsewhere in the body.

TREATMENT

Regarding medical treatment, it can be said that apart from a non-roughage diet and general supportive measures nothing can be done to help the patient with ileitis. A direct therapeutic attack, in the absence of knowledge regarding the etiology, is impossible. In the cases of diffuse, almost universal involvement of the small intestine, one is forced to use medical means alone since the widespread anatomical distribution defies surgical measures. Surprisingly, these cases sometimes seem to improve under such simple measures, at least for the time being. Two such cases of diffuse ileojejunitis in which patients were not operated upon have been under observation for several years. One patient has gained as many as 50 pounds in weight under simple non-roughage diet and paregoric. The latest x-ray studies continue to show the lesion, but the general well-being of patient and inutility of surgery encourage further expectancy.

Surgery is the treatment of choice in all except acute cases of ileitis, and resection is probably the procedure which offers the best chance of permanent cure. I have no serious quarrel with any surgeon who prefers a short-circuiting operation to resection because of its lower risk, that is, 10.5 per cent, provided he understand that the patient has only an even chance of cure by this more conservative procedure. The notes of the 20 cases in which a short-circuiting operation had been performed, usually an ileocolostomy with transection and exclusion of the diseased ileum, disclosed the fact that exactly one-half or 10 patients are apparently well after a follow-up of 2 to 3 years. The 10 other patients did badly and had to submit to subsequent resection with a considerably higher, operative mortality. A primary resection can be undertaken with a moderate but not inconsiderable mortality, the rate being 15 per cent of 52 resections, but it offers the greater chance for permanent cure.

Unfortunately, one can no longer deny a certain percentage of recurrences even after what seems to have been a radical and sufficient resection (15, 19). The proportion at Mt. Sinai Hospital has been 3 cases out of 39 operated upon, or 7.7 per cent. These recurrences can be explained only on 1 basis, namely, the inability of the surgeon to recognize the upper limit of mucosal involvement. Perhaps the enlarged mesenteric lymph nodes are not an infallible guide to the extent of the lesion; perhaps the advanced upper limit of infiltration is so minimal and so restricted to the mucosa as to create no hyperemic or inflammatory reaction in the serosa, thus defying detection by either inspection or palpation. We know that skip areas may leave as many as 12 to 18 inches of free uninvolved mucosa between minimal areas of diseased tissue. Recognition of these facts, and a most meticulous search of the entire ileum at the time of exploration may diminish or eliminate the chances of recurrence and lead to still greater improvement in an otherwise eminently satisfactory field of surgical endeavor.

REFERENCES

1. Brown, P. W., Bargen, A. J., and Weber, H. M. Proc. Staff Meet. Mayo Clinic, 1934, 9:331.
2. Clute, H. M. Surg. Clin. N. America, 1933, 13:561.
3. Colp, R. Surg. Clin. N. America, 1934, 14:443.
4. Crohn, B. B., Ginzburg, L., and Oppenheimer, G. D. J. Am. M. Ass., 1932, 99:323.
5. Crohn, B. B., and Rosenak, B. J. Am. M. Ass., 1936, 106:1.
6. Crohn, B. B. Am. J. Diges. Dis. and Nutr., April, 1934, 1:97.
7. Idem. Tr. Am. Proctol. Ass., 1937.
8. Crohn, B. B. and Penner, A. Ann. Surg., 1938, 108:867.
9. Felsen, J. Am. J. Digest. Dis. and Nutr., 1935, 1:782.
10. Idem. Am. J. Roentgenol, 1937, 37:190.
11. Harris, F. L., Bell, G. H., and Brunn, H. Surg., Gynec. & Obst., 1933, 57:637.
12. Homans, J., and Hass, G. M. New England J. Med., 1933, 209:1315.
13. Kantor, J. L. J. Am. M. Ass., 1934, 103:2016.
14. Koster, H., Kasman, L. P., and Scheinfeld, W. Arch. Surg., 1936, 32:789.
15. Lewisohn, R. Surg., Gynec. & Obst., 1938, 66:215.
16. Mixter, C. G. Ann. Surg., 1935, 102:674.
17. Mock, H. F. Surg., Gynec. & Obst., 1931, 41:672.
18. Moschcowitz, E., and Wilensky, A. O. J. Med. Sc., 1923, 166:48.
19. Oppenheimer, G. D. J. Am. M. Ass., 1938, 110:1103.
20. Probstein, J. G., and Gruenfeld, G. F. Ann. Surg., 1936, 103:273.
21. Reichert, F. L., and Mathers, M. E. Ann. Surg., 1936, 104:601.
22. Snapper, I. Pseudotuberculosis in man. Amsterdam, Holland, 1938.
23. Idem. An. de med., 1936, 39:1.
24. Sproul. Am. J. Roentgenol., 1936, 36:910.
25. Tietze, A. Ueber entzuendliche Dickdarmgeschwulste. Ergebn. d. Chir. u. Orthop., 1920, 12:211.

REGIONAL ENTERITIS

CHARLES G. MIXTER, M.D., F.A.C.S., Boston, Massachusetts

FOR many years reports of benign nonspecific intestinal granulomas have appeared in medical literature but no attempt had been made to classify these lesions until 1932 when Crohn, Ginzburg and Oppenheimer segregated from the general group of granulomas one having apparently definite clinical and pathological characteristics. Their experience was based on a series of 14 cases, in every instance of which the pathological process was sharply limited to the lower segment of the small bowel. In 13 of these cases a pathological study of the resected specimens showed a chronic inflammatory process with apparent limitation of the distal progress of the lesion by the ileocecal valve. On this basis they created a clinical and pathological entity which they termed regional ileitis.

The stimulus of this first communication is evidenced by the voluminous bibliography that has accumulated in the intervening 6 years. It soon became evident that the term regional ileitis was not sufficiently comprehensive, because of increasing reports of cases showing extension of the process to the colon and proximal small intestine either by contiguity or with intervening areas of apparently normal intestine. Even massive involvement, extending from the ileocecal valve to the ligament of Treitz has been encountered. For this reason the term, "regional ileitis," has been generally supplanted by the term, "regional enteritis," or "chronic cicatrizing enteritis."

The salient clinical and pathological features of the disease are as follows: It is a disease of youth. Fifty-five per cent of our 20 cases were under 25 years of age and 18 were less than 35 (9). The cause is unknown. Primary infection of the appendix spreading to the ileum (4), bacillary dysentery (2), and a possible relationship to lymphogranuloma inguinale (12) have been suggested. A superficial resemblance between mesenteric lymphadenitis and regional enteritis (5) has led to the supposition that both may possibly be due to a low-grade primary infection of the lymphatic system. Although cultures from the lesion are usually either sterile or mixed, there are several reports in the literature of the isolation of a streptococcus (8, 10). In 2 of our less advanced cases an anaerobic streptococcus was obtained in pure culture from the free peritoneal fluid and from the cut surface of the mesenteric glands. However, we have been unable to reproduce the lesion in animals with this organism. Stagnation at the ileocecal valve and bacterial absorption through the rich lymphatic supply at the ileocecal angle have been considered accountable for the greater frequency of involvement of the terminal ileum (11). In no case has the tubercle bacillus been demonstrated.

The clinical features of regional enteritis are those of a low-grade inflammatory lesion of the intestinal tract, often of months' or years' duration. The signs and symptoms depend on the location, extent, duration, and severity of the process. The disease is progressive, though at times marked by remissions and exacerbations. Long latent periods may occur. Although spontaneous cure may take place, the definite establishment of this contention has yet to be confirmed by a long period of observation or by pathological demonstration in operatively proved cases.

The different stages of the disease are not sharply defined, but the 4 clinical phases described by Crohn and his co-workers have been generally accepted by subsequent observers. In the first phase the symptoms and signs are those of peritoneal irritation, namely, pain in the right lower quadrant, fever, leucocytosis, tenderness, and spasm. It is this stage that has so often been erroneously diagnosed as acute appendicitis and in which operation has disclosed an edematous injected loop of terminal ileum with edema and hyper-

From the Surgery Departments of Harvard Medical School and Beth Israel Hospital.

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

plastic adenopathy of the mesentery and an excess of free peritoneal fluid. The appendix is not involved. Little opportunity for pathological study of this stage has been afforded as surgeons have felt that resection was not warranted in most instances.

The next step in the progress of the disease is the onset of symptoms suggestive of a mild ulcerative colitis: cramp-like abdominal pain, frequent loose bowel movements with mucus and rarely a small amount of blood, bouts of fever, weakness, and generally a marked loss of weight. There is low abdominal tenderness, and a mass may be palpated. Unlike colitis, tenesmus is absent and no ulcerations are disclosed on proctoscopic examination. Anemia and leucocytosis are commonly present. Perianal lesions, such as abscesses or fistulas, are not infrequently noted.

At this time the diseased segment appears thickened and edematous but less injected, and the serosal surface is granular and somewhat suggestive of miliary tuberculosis, though the nodules do not tend to bleed as readily. The mesentery is much thickened and the adenopathy is extreme. There is a tendency of the affected loop to agglutinate to surrounding structures.

On opening the resected specimen one is struck by the thickening of the intestinal wall, the definition of its layers due to edema especially of the submucosal layer. Numerous mucosal ulcerations appear particularly along the line of the mesenteric attachment. The lesion gradually shades off into normal bowel as it is followed orally from the ileocecal valve; but at times another area of disease may be found separated from the original lesion by an intervening segment of normal ileum.

The third stage is that of chronic partial intestinal obstruction. Severe colicky pain, distention, nausea and vomiting are present. Constipation may replace the previous diarrhea, but complete obstruction very rarely occurs. A mass is almost always palpable.

The diseased bowel is rigid and hose-like and the wall is tremendously thickened with consequent encroachment on the lumen. The mucosa has a cobble-stone appearance, the healing and contracture of the ulcerations throwing intervening areas of uninvolved mucosa into prominence. An extreme degree of this condition produces polypoid masses that further obstruct the stenosed intestinal lumen. Above the stenotic area the lumen of the bowel is dilated but gradually diminishes with decreasing abnormality of its wall and lessening of the mesenteric edema. A complete return to normal intestine may be reached only several feet above the area of greatest activity.

There is a tendency to the formation of sinuses and fistulas in regional enteritis and such complications form the fourth phase. They are the result of slow perforation of the mucosal ulcers. Acute perforation is of extreme rarity and has occurred only in the upper small bowel in reported cases. One such instance appears in our series. Slow perforation of an ulcer at the mesenteric attachment may take place with the formation of a blind sinus or an abscess between the leaves of the mesentery or adjacent intestinal coils. As the diseased loop tends to adhere to adjacent structures, perforation of the ulcers may lead to internal fistulas, commonly to the cecum and ascending colon, then to the sigmoid, transverse colon, other loops of the small intestine, and occasionally to the bladder. Persistent draining sinuses, usually in the scar of a previous appendectomy incision, are not uncommon. At times numerous surgical attempts to close such sinuses have failed until resection of the underlying diseased bowel has been done.

Much stress has been laid on the value of roentgenographic examination in the diagnosis of regional enteritis. In the early development of the lesion no abnormality will be revealed but only the inconclusive evidence of hypermotility of the bowel, perhaps accompanied by cecal spasm. As the disease advances to the obstructive form, a definite filling defect in the ileum is observed with proximal stasis and dilatation. Increasing stenosis diminishes the bowel lumen until only a fine line of barium, the "string sign" of Kantor, is seen leading to the ileocecal valve. The string sign is not pathognomic but is extremely suggestive of the diagnosis. In our experience intestinal films taken at hourly intervals furnish the most accurate data. The

barium enema will at times demonstrate a positive string sign and is helpful in defining internal fistulas and pressure defects on the colon from abscesses or agglutinated masses of the small bowel.

No attempt will be made to discuss the differential diagnosis, but it should be emphasized that regional enteritis should always be considered when a young adult complains of symptoms of partial intestinal obstruction accompanied by the signs of a low-grade inflammatory process. A somewhat prolonged history of colic-like abdominal pain, irregular bowel habit, loss of weight, slight fever, and leucocytosis, is highly suggestive. Distention, a palpable mass on abdominal or rectal examination, and the demonstration of the string sign on x-ray investigation confirm the diagnosis.

The time has been too short and the number of cases observed too few in any one clinic to permit the establishment of a fixed policy in the treatment of regional enteritis in its different stages. In the hope of obtaining information that would be of value in setting up a general technique of management, a questionnaire was sent to a limited number of clinics and surgeons in the United States. Thirty-seven answers have been received and the data on 363 cases have been submitted for analysis from 31 individuals or clinics. The 6 other replies state that no instances of regional enteritis had been encountered. Only pathologically or operatively proved cases have been included in the series evaluated below. The follow-up period has ranged from a few months to over 6 years, the majority having been observed for longer than 1 year. The largest single series was that of Crohn, 77 cases with operation in a total of 110 cases personally followed.

The adequate appraisal of the results of treatment, be it medical or surgical, demands definite criteria by which the presence of persistent or recurrent disease may be determined. Obviously the return of persistent diarrhea, fever, and weight loss mean renewed activity of the lesion. However, many patients who have been restored to normal efficiency subsequent to radical surgical treatment, give evidence of some degree of hypermotility of the bowel by x-ray and by the passage of 2 or 3 semi-formed or loose bowel movements a day. They have gained in weight and consider themselves well.

The presence of hypermotility is not in itself evidence of recurrence. Massive small intestinal resections for lesions other than regional enteritis may be followed by persistent hypermotility, for example:

A 38-year old man had an extensive small bowel resection for mesenteric venous thrombosis. Between 4 and 5 feet of gangrenous small bowel were removed. At the present time he is in good health, attends to his profession as lawyer, but passes an average of 3 loose stools daily. An x-ray examination 18 months after operation showed marked hypermotility, and moderate dilatation of the distal loops of the ileum.

From a detailed review of 257 cases of massive resection of the small bowel Haymond concluded that diarrhea was the most common and distressing postoperative disturbance. Consequently, a diagnosis of recurrence of regional enteritis should rest not only upon the evidence of hypermotility but also on the presence of bouts of fever, persistent diarrhea, and loss of weight characteristic of the disease.

Of the 363 cases gathered by our questionnaire 278 have been subjected to major surgical procedures, and the total surgical mortality has been 14 per cent. Twenty-five of the 27 surgeons who operated upon these patients consider radical resection in one or more stages as the treatment of choice in all but the earliest phase of the disease.

Although radical resection of the diseased bowel has been the most widely practised surgical measure, the follow-up studies show a very considerable percentage of recurrences. Koster, Kasman, and Sheinfeld reported 15 per cent of recurrences in 126 cases collected from the literature. Analysis of the material placed at our disposal shows a 20 per cent recurrence in the entire group in which operation was done. These recurrences appeared within periods varying from 4 months to 6 years. As one would surmise there is a far greater liability to recurrence in the advanced stages, so that it is clear that the optimum time for surgical intervention is in the earlier periods. Comparison of the statistics of medical and surgical treatment is manifestly

meaningless as patients presented for resection in most instances have progressed unfavorably under previous medical supervision. Furthermore, medically treated patients are not necessarily proved cases of the disease.

The treatment of regional enteritis can be best considered for each of its clinical stages. Surgical intervention in the acute stage is generally conceded to be unwise. Spontaneous resolution may occur. The danger of disseminating an acute infection by operative handling is possible. When the abdomen is opened under an erroneous diagnosis and an acute regional enteritis is encountered, incidental appendectomy should not be performed. Although in the past we have been guilty of this procedure in a few instances in our series at the Beth Israel Hospital, it is unsound to remove an appendix that is not implicated as a causative factor in the disease, in the presence of an acute infection. In addition, the risk of establishing an external fistula is great in a disease characterized by its tendency to fistula formation. The considerable number of patients presenting themselves with fistulas, frequently fecal in character and following a previous unnecessary appendectomy, is good evidence of this danger.

Accepting conservative measures as the preferable method of treatment in the acute stage, the progressive tendency of the disease must be kept constantly in mind. A strict medical regimen must be maintained with sufficient rest and a bland diet. If, after an adequate trial of from 3 to 6 months, the patient's condition continues to deteriorate, or should the signs of obstruction or other complications appear, a surgical approach should be considered.

There are no clearly defined boundaries between the clinical stages of regional enteritis; one phase merges gradually into another. Thus, early in the second or ulcerative stage where slight fibrotic changes have occurred, it is possible that complete regression to normal may spontaneously take place. But late in the same stage when infiltrating fibrosis has rendered the bowel rigid and inelastic and when encroachment on the lumen is already considerable though insufficient to produce obstructive symptoms, it is hardly conceivable that restitution to normal can occur. If medical measures have failed to halt the progress of the lesion thus far, obstruction or fistula formation may be expected to follow. Surgical intervention should be employed before such developments take place.

In this stage the indications for radical resection are marked fibrotic changes in the intestinal wall and extensive mesenteric adenopathy. A wide excision of the diseased bowel and its mesentery, preferably in one stage, gives excellent results. We believe that the importance of an extensive excision of the involved mesentery should be emphasized, as it is possible that insufficient removal may be responsible for recurrence when the intestinal resection has appeared adequate. For this reason we consider resection and anastomosis preferable to a Mikulicz procedure in dealing with this condition.

The treatment of the advanced stages of the disease is unquestionably surgical. Graded procedures may be necessary. The patients are debilitated, and in the latest stages nutritional disturbances such as peripheral edema, neuritis, and anemia are often present. The common complications of abscess and fistula usually do not lend themselves safely to primary resection.

Obstruction, when present, is rarely complete and with appropriate pre-operative preparation a lateral anastomosis for its relief is usually permissible, though occasionally a preliminary ileostomy is indicated. The stoma should be placed well away from the upper limit of the lesion but an anastomosis in continuity should be avoided if possible. An unexpected delay in the performance of the resection may give the disease an opportunity to progress upward beyond the anastomosis and implicate the proximal intestine. As a curative measure the short circuiting procedures have never proved successful in our hands but apparently have been in the hands of others. However, the expression of opinion we have received is so strongly in favor of extirpation of the lesion that anastomosis must be considered merely a step toward the ultimate resection, when the patient's condition warrants the major procedure.

Fistulas commonly form between the terminal ileum and the cecum or ascending colon, and in this location can be readily dealt with at the time of the resection. When the fistula runs to the sigmoid it is not unusual to observe some evidence of the disease in the large bowel in this area. The wall is injected, somewhat thickened, and the serosa is granular. The sigmoid mesentery does not show the edema and adenopathy that is present in the mesentery of the ileum. Resection of the sigmoid is not necessary and the lesion may be expected to subside following simple closure of the fistulous opening. Bladder fistulas, though of rare occurrence, may be similarly treated.

In a limited experience with the surgical treatment of multiple lesions involving the ileum and the sigmoid, the results have been far from satisfactory.

One patient, following graded resections of both lesions, showed gratifying improvement for 5 months. She then developed a fulminating recurrence with severe diarrhea. An end ileostomy was performed in a desperate attempt to afford relief. She died of peritonitis on the fourth postoperative day and at autopsy 4 perforations of the jejunum were found. There was massive involvement of the small bowel and of the colon to a lesser degree.

Lesions high in the small bowel appear to present the most virulent characteristics and it is in this situation that acute perforations into the free abdominal cavity occur. From our experience and that of others reported in the literature it would seem wise when possible, to avoid surgery in such cases.

SUMMARY

Much remains to be learned about regional enteritis. The etiology must be ascertained and the life history of the disease must be adequately traced. Unquestionably with advancing knowledge, our conception of the proper treatment will alter. At the present time it would appear that medical management is indicated in the acute stage of the disease. With continued progression in spite of an adequate period of intensive medical therapy, radical surgical resection in one or more stages should be instituted. The outlook for restitution of health and prolonged arrest or cure of the disease is good. Although it is impossible to state the actual number of cures in this series because of the wide variation in the period of follow-up, it is evident from a study of the answers to our questionnaire that the operative mortality in the more complicated cases was much higher than in the simple or less complicated ones; and it is obvious that persistence in conservative therapy in these latter groups will work to the disadvantage of the patient.

The treatment of the advanced stages of the disease with obstruction, abscess or fistula, is clearly surgical. Multiple stage procedures should be utilized, the final objective always being the resection of the involved bowel. The patient's condition is frequently precarious and a high mortality must be faced. It must be recognized also that the chance of recurrence is far greater than when dealing with the less advanced lesion. Nevertheless, as the patient's progress is persistently downward and medical measures are futile, operation should be advised as offering the only opportunity for a return to health.

I wish to express my thanks for the co-operation and work required by the surgeons who kindly answered my questionnaire.

REFERENCES

1. Crohn, B. B., Ginzburg, L., and Oppenheimer, G. D. Regional ileitis, pathologic and clinical entity. J. Am. M. Ass., 1932, 99: 1323–1329.
2. Felsen, J., and Gorenberg, H. Chronic dysentery, distal ileitis, and ulcerative colitis: a follow-up of the Jersey City epidemic of bacillary dysentery. Am. J. M. Sc., 1936, 192: 553–556.
3. Haymond, H. E. Massive resection of small intestine, etc. Surg., Gynec. & Obst., 1935, 61: 693.
4. Homans, J., and Hass, G. M. Regional ileitis: a clinical not a pathological entity. New England J. Med., 1933, 209: 1315–1324.
5. Jackson, A. S. Regional enteritis. Surg., Gynec. & Obst., 1937, 65: 1–10.
6. Kantor, J. L. Regional (terminal) ileitis; its roentgen diagnosis. J. Am. M. Ass., 1934, 103: 2016–2021.
7. Koster, H., Kasman, L. P., and Sheinfeld, W. Regional ileitis. Arch. Surg., 1936, 32: 789.
8. Mailer, R. Acute regional ileitis, etc. Brit. J. Surg., 1938, 25: 517.
9. Mixter, C. G., and Starr, A. Further experience with regional enteritis. New England J. Med., 1938, 219: 37–40.
10. Mixter, C. G. Regional ileitis. Ann. Surg., 1935, 102: 674–694.
11. Probstein, J. G., and Gruenfeld, G. E. Acute regional ileitis. Ann. Surg., 1936, 103: 273.
12. Stafford, E. S. Regional ileitis and ulcerative colitis. Bull. Johns Hopkins Hosp., Balt., 1938, 62: 399–407.

THE MEDICAL TREATMENT OF BRONCHIECTASIS

J. J. SINGER, M.D., Los Angeles, California

IN the study of pulmonary lesions it is absolutely necessary to have a correct diagnosis. Before the use of iodized oils, statistics on bronchiectasis were misleading because many cures which were reported by bronchoscopic drainage and various drugs and operations were due to spontaneous cures of lung abscesses, chronic pneumonitis or even fungus diseases of the lungs. A positive diagnosis can now be made by proper instillation of iodized oils into the bronchial tree. Then and then only, can we be sure as to whether bronchiectasis is present or not.

In the neglected cases of bronchiectasis one frequently finds that the evidence of metastatic abscess in the brain or kidney and even amyloidosis overshadows the underlying pathology. Obviously, treatment must be applied to the bronchiectatic condition as well as to the other organs. Unfortunately, when these severe complications are present little can be accomplished by any form of treatment.

In the bronchiectasis found developing in children after measles or whooping cough, occasionally the condition clears spontaneously, particularly if the lesion is not present too long. The foreign body lesions frequently heal when the foreign body is either coughed up or removed bronchoscopically.

Before specific medical treatments are described it seems advisable to discuss the various types of bronchiectasis, the etiological factors, and clinical features.

TYPES OF BRONCHIECTASIS

There are two main types of bronchiectasis, universal and telangiectatic. The universal type is a general form which is said to affect an entire bronchus, while the telangiectatic form is the conversion of the lung as a whole, or in part, into a mass of cysts lined with light epithelium. In the latter form cysts sometimes occupy the entire chest cavity, and it is difficult to differentiate the condition from a spontaneous pneumothorax.

In the acquired form of bronchiectasis the disease is usually secondary to infection following inhalation of a foreign body into the bronchial tree, or the condition may follow the pneumonias associated with the exanthematous diseases.

Tuberculosis is frequently a precursor of dilatations of the bronchi. This is usually due to the fibrosis resulting in stenosis of some of the bronchi followed by infection and secondary dilatations. The physical changes in the lung are due, however, more to mechanical causes than infection. Mediastinal swellings, compression of the lung by fluid or by tumors, may secondarily produce bronchiectasis of irregular shapes. Tumors within the bronchi frequently act like foreign bodies and produce similar dilatations of the bronchi beyond the obstruction.

David T. Smith suggests that bronchiectasis could be produced by lesions associated with fusospirochetal infection. He states that the elastic tissue of the finer bronchi is weakened and may even rupture by the action of an aerobic group of organisms.

The age of the patient, the duration of the disease, acute exacerbations of infection, the physical state of the patient, particularly the condition of the upper respiratory tract, and also the condition of the heart, kidneys, and so forth, are important factors to be considered in a discussion of treatment.

CLINICAL FEATURES

Nearly all cases of bronchiectasis are more or less associated with pulmonary abscess. The duration of the disease is usually of many years' standing in adults and one can frequently trace the origin in most cases to pulmonary diseases in childhood or even infancy.

The complaints are not typical. The secondary complications, such as bronchitis, abscess, or pleuritic involvement, are the

From the Chest Service, Cedars of Lebanon Hospital.

Presented before the Clinical Congress of the American College of Surgeons, October 17–21, 1938. A paper presenting the "Surgical Treatment of Bronchiectasis" was read by Norman S. Shenstone and has been published elsewhere.

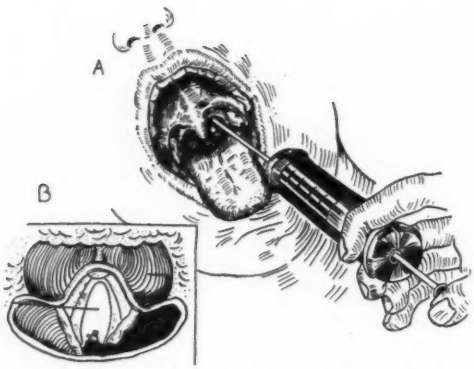


Fig. 1. A, Aspiration method of injecting lipiodol. Note the straight cannula placed between the uvula and the tonsil. B, The oil is shown filling the inner arytenoid fossas and dripping into the larynx when the patient takes a deep breath.

symptoms which call for attention. Cough is the most important and frequent complaint. It is usually severe and persistent during a great part of the day and night. The secretion brought up varies in amount from a few cubic centimeters to 800 or 1000 cubic centimeters. It may be foul or bloody. At times the expectoration is so foul that it is not only disgusting to the family but to the patient himself. Fever, sweats, and chills are frequently associated with the disease but only when secondary abscesses are present. It is not unusual for recurrent attacks of so called pneumonitis to develop which in time may be followed by metastatic abscess of the brain, kidney, and in late stages, with amyloidosis. Many patients have hypertrophic osteoarthropathy (club nails) particularly if the condition is of long standing.

The physical findings are vague in the chest. At times râles are present in one or both lower lobes. The character of these varies with the amount of secretion. Dullness on percussion is rare but increased whisper signs over the affected area may be the diagnostic sign. If drainage is accomplished by position, the increased whisper sounds are particularly loud.

It is the roentgenographic study of the lungs which establishes the diagnosis positively, particularly when iodized oil is injected into the bronchial tree. This can be done easily. The patient faces a good light and is told to open his mouth as widely as possible; his tongue is grasped with a piece of gauze and is pulled out as far as possible. Iodized oil, which has previously been warmed in a syringe, is slowly injected into the postpharynx through a straight cannula while the patient breathes deeply. The patient is instructed not to swallow or cough during the injection. Local anesthesia is seldom necessary although in nervous patients it is advisable to use 1 per cent procaine as a spray to the pharynx. The roentgenogram after injection shows the various types of dilatation.

TREATMENT

It is quite evident from the descriptions given that no definite or specific treatment can be used for such a complex condition of bronchiectasis. A cure can be affected only when the diseased portion of the lung or the entire lung, if it is unusually involved, is removed surgically.

Much can be done, however, to relieve the symptoms which at times are most distressing. It should be appreciated that the infection of the bronchiectatic areas sometimes becomes quiescent and the symptoms of cough and expectoration disappear. The patient, and sometimes the physician, may think the patient is well although in many such cases the introduction of the iodized oil into the bronchi will demonstrate the presence of the dilatation just as before the so called cure.

Among the medical treatments suggested for bronchiectasis are the following: rest, diet, climate, postural drainage, thirst cure, heliotherapy, intravenous therapy, direct intrabronchial application of drugs, irrigation of the lung (bronchial lavage), inhalation of vapors, vaccine therapy, bronchoscopy, artificial pneumothorax, abdominal belts, and oleothorax. So many treatments are offered but none of them has really done much to cure the patient, but the symptoms have been much ameliorated.

Rest. As in most pulmonary diseases, rest is an essential part of the treatment. The healing factors of the body are best able to function when there is freedom from exercise and work. It has been shown by Pritchard

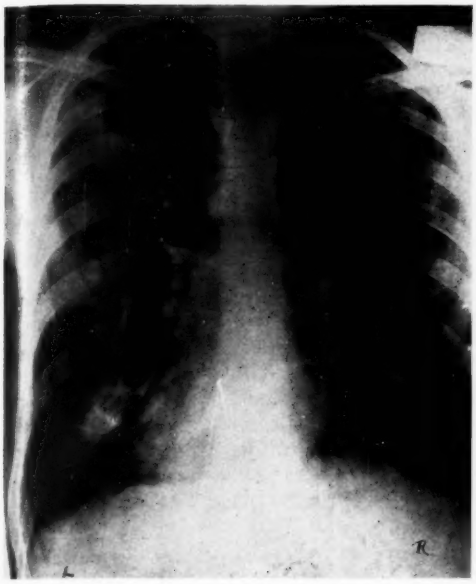


Fig. 2. Roentgenogram of a patient with bilateral bronchiectasis. One can see some irregular densities in both bases and hilar regions. (See Fig. 3.)

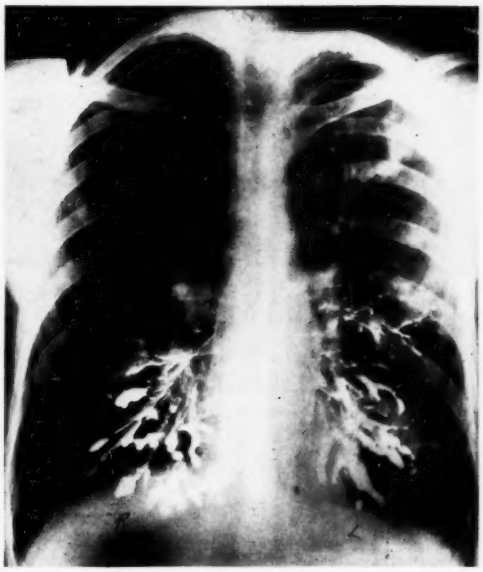


Fig. 3. After lipiodol injection one notes the true condition of cylindrical and clubbing bronchiectasis of both lungs. Without the oil no definite conclusion could be had concerning the pathological condition of the lungs.

that when patients with bronchiectasis are put to bed they cough less, gain weight and are generally better. The rest need not be as strict as in tuberculosis. Even when strict and prolonged, rest alone will not cure bronchiectasis.

Diet. Diet should be simple and sufficient to provide caloric requirements which are increased whenever there is fever. No specific restrictions are indicated. Care should be taken to provide an adequate protein and vitamin intake. Vitamins may play an important part but as yet nothing definite has been proved of value in this disease.

Climate. Close study of accumulated experience suggests that climate alone never cured bronchiectasis. It is undoubtedly true, however, that temporary, and in some cases, long lasting improvement results from change in climate. Some patients have apparently benefited from the dry, sunny climates of Arizona and New Mexico; others from the mountains or the seashore. In resistant cases, the desirable effects of climate should be tried whenever economic conditions permit.

Postural drainage. Of all the measures for symptomatic relief, postural drainage is the most effective. While the method is simple,

Fig. 4. Classification of bronchiectasis: 1, grape; 2, clubbing; 3, cylindrical; 4, saccular; 5, bead formation. (From Ballon, Arch. Surg., 1927, p. 184.)

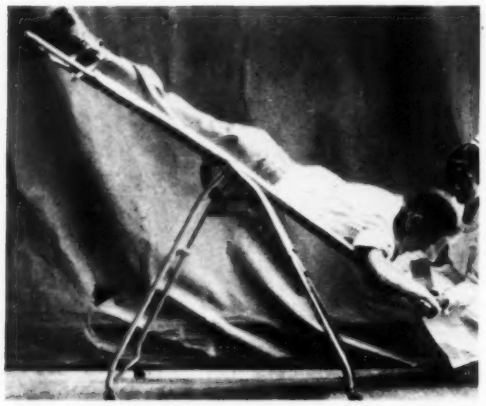


Fig. 5. Postural drainage table (Singer) made of metal tubing with a pivot and brake arrangement at center of table top. It is not necessary to tip the patient more than 5 minutes, 2 or 3 times a day.

detailed directions must be given patients if the most benefit is to be obtained. By observation of their own case some patients find that considerable drainage is obtained in certain positions and they are able to relieve themselves of large quantities of purulent sputum with little difficulty. It is obvious to this type of patient that the recommendation of postural drainage tables or beds are not advisable. The simplest form of postural drainage is the use of a see-saw arrangement whereby a long board is attached to a carpenter's horse and the patient inclines himself at the proper angle (Fig. 5).

A postural drainage bed has also been devised by the author (Fig. 6). In this bed the patient can be placed without any effort, in almost any incline for drainage. The apparatus is simple and the various positions can be obtained by moving certain levers.

Another simple means for obtaining postural drainage is by kneeling on a chair with the hands on the floor. The length of time for each drainage varies with the pulmonary conditions, but usually should not be over 2 to 5 minutes at a time. If drainage is obtained easily, it should be done two or three times a day. This keeps the bronchi empty most of the time and permits many patients to go about their work and play without discomfort. Drainage before bedtime is particularly helpful. In many cases the benefit derived from postural drainage is dramatic and the patient frequently believes that he is cured. Improvement may be prolonged but the underlying condition is not corrected.

Of great importance is the correction of chronic upper respiratory conditions and unless these conditions are attended to, other treatment is not effective. At this point one might mention the importance of close co-operation between the otolaryngologists and the physician. The attempt on the part of the physician to treat bronchiectasis alone meets with failure if there is a lack of co-operation.

The acute exacerbation in bronchiectasis is due frequently to conditions arising in the upper respiratory tract, and any treatment directed toward this condition may prevent aggravation of a pathological state in the lung which is always present in bronchiectasis.

Heliotherapy. This method of treatment has been given considerable attention, but so far no change in the pulmonary lesions has been noted other than the general effects obtained by sunlight.

Intravenous therapy—neoarsphenamine. This drug is given in similar doses as in the treatment of syphilis and occasionally one sees a clearing up of symptoms, particularly in the amount of sputum which is reduced, and the fetid odor which may be present disappears. But the number of patients who have been much benefited so far are few. There are some who prefer to give neoarsphenamine in minute doses frequently repeated, but observation of results leads to the conclusion that one cannot expect too much from this mode of treatment. When properly given there is no harm in the use of this drug, and it seems to be worthwhile when administered in addition to other treatments, particularly postural drainage and rest. Other drugs have been tried with even less benefit.

Intrabronchial application of drugs. Lipiodol and other iodized and bromized oils have been recommended as a treatment for bronchiectasis. The method of introducing the oil has been described previously (4). It might be well to note that the oil is a combination of some oil with iodine, and that the mixture is a physical rather than a chemical one; and

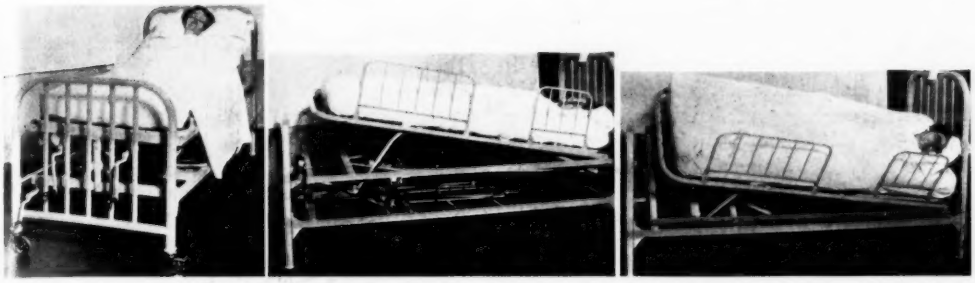


Fig. 6. Postural drainage bed (Singer) found useful for patients who are too ill for the drainage table, and for postoperative positioning. The various positions are obtained by turning appropriate levers.

that the iodine content does not separate from the oil except in the gastro-intestinal tract where it is slowly absorbed and the iodine is eliminated through the kidneys. There is nothing in the iodized oil which prohibits the growth of bacteria. In fact it has been shown that the oil on agar plates does not prevent the growth of adjoining colonies of Bacillus coli, Staphylococcus aureus and Streptococcus hæmolyticus.

Since the iodized oils are not bacteriostatic, little effect might be expected from the introduction of 20 cubic centimeters of oil every 2 weeks. The effect of the oil is due to its weight which permits it to cover the bronchial walls with a coating of oil. This may, in a measure, prevent irritation of the mucous membrane by retained pus and organisms. It tends also to liquefy and to dilute the secretions so that in coughing the discharge is more easily expectorated.

There are certain patients who have an idiosyncrasy for iodine or bromine in any form, and it is always advisable to find out whether such a condition exists before the introduction of these oils into the lung. In these patients even a small amount of the oil may produce coryza, increased cough, and feeling of malaise. The oil should not be injected more often than once a week and the amount should vary between 10 and 20 cubic centimeters. It should be warmed to body heat before its introduction and should be introduced with the least possible mechanical disturbance. If one does not obtain good and positive results within 3 or 4 weeks, it is not advisable to continue the treatment.

Bronchial irrigation (*lavage*). This method of treatment has been suggested as far back as 1914 by Yankauer. It was done through a bronchoscope or by a soft rubber Condé catheter. Stitt and Wooding, employing a hypertonic mixture of a saline solution, report 35 per cent symptomatic cures in a series of 250 cases. For the study of the value of bronchial irrigation, this method employed is worthwhile, but we have found, in our own experience, that postural drainage with an occasional bronchoscopic aspiration served the same purpose. With all the benefits derived from lavage, the bronchial dilations still persisted.

Inhalations of medicated air and volatile drugs. The inhalations are not recommended. Many physicians, however, particularly in Europe, have developed chambers containing medicated air and have recommended it to patients with bronchiectasis. It is hard to believe how any such inhalations can improve the state of the bronchial tubes.

Vaccine therapy. The autogenous or stock vaccines made from various mixtures of bacteria, that are present in the respiratory tract, have been recommended. In our own experience this has been of very little benefit even symptomatically. There are, however, many men who have used this treatment, particularly the autogenous form of vaccine and it would be quite difficult to argue the value of such treatment with those who believe in it. But the author cannot recommend it at this time. It is possible, however, that the experimental studies may eventually bring forth a vaccine that may be of considerable benefit.

Roentgen therapy. This method of treatment has been suggested by several authorities. The logic of the treatment is that the fibrosis of the lung can be produced which may in time, by the shrinking of the lung, close the bronchi and prevent puddling of secretions within them. While the clinical reports seem encouraging, it does not seem probable that a great deal of permanent good can result. In fact, when one considers that bronchiectasis is often produced by fibrosis, an uncontrolled fibrosis produced by roentgenotherapy may be just as bad as if the fibrosis was due to inflammation. Further studies with dosage and proper material may show that there is some benefit in the use of the roentgenotherapy. It is by no means a closed book. Cases described by Berck seem to have shown some improvement clinically.

Use of the bronchoscope. The use of the bronchoscope has received considerable attention. Its value for diagnosis or for drainage of the bronchial tubes is not disputed. One of the greatest benefits derived from the use of the bronchoscope is the ability of the operator to dilate some of the bronchi and to remove some of the granulation tissue when it is within the optical field.

Whether patients have been cured by its use is another matter. There are many bronchi which cannot be aspirated, either because there is a stenosis or because they are too far away from the main stem bronchus. Therefore, the secretions retained in these areas may become inspissated with the possibility of small abscess formations. The bronchial tree can be compared to a large sponge with the inflammatory conditions narrowing bronchi here, and producing dilatations there. The affected lobe or lobes are in such a physical state that drainage cannot be established from all its openings. Therefore, drainage through the bronchoscope can at best be only partially effective. One cannot expect that aspiration of pus from the bronchial dilatations will lead to cure when the bronchial walls are thickened by inflammatory tissue. The symptoms, however, are frequently relieved enough to permit the patient to carry on his daily activities. In a comparison with postural drainage, the bronchoscope may drain out dilatations more quickly but the treatment is not a pleasant one and certainly is expensive.

In the active attempt to treat bronchiectasis with a bronchoscope, some men have gone too far particularly in the frequency and the length of time the bronchoscopic drainage has been done. It is the opinion of the writer that if no positive benefits are derived within the first few months, surgical methods should be considered in patients who are otherwise found suitable.

Pneumothorax. Treatment by means of artificial pneumothorax has been extensively advocated; however, since the use of iodized oil has become established, the enthusiasm for this treatment has diminished. It has been found that even when the lung is well collapsed the bronchial dilatations are still present after the collapse of the lung. One might wonder how compression of a diseased lung in which there is fibrosis, with thickened and dilated bronchi, can be effective in changing these factors. It appears that the explanation of the improvements following pneumothorax treatment is based on the fact that the lung as a whole is put at rest and that as a result, natural recuperative processes may become more effective. Drainage from some of the bronchi may be better as a result of a change in the direction of the bronchi by the pneumothorax. Symptomatic relief is occasionally sudden and dramatic but in the majority of instances no permanent benefit has resulted. It is customary to inject 200 to 300 cubic centimeters at a time, repeated as frequently as the air is absorbed and the lung re-expands. One should discontinue treatment after a few months if definite improvement fails to manifest itself.

Oleothorax. When there is improvement from pneumothorax or when there is difficulty in continuing the treatments, oleothorax may be instituted. In a few instances improvement has resulted when this method has been used. The lung can be kept compressed for several years.

The oil injected consists of 95 per cent liquid paraffine or olive oil to which is added 5 per cent gomenol. The treatment should be started with only a few cubic centimeters of

the oil injected into the pleural cavity to test the reaction of each patient to the oil. Two hundred cubic centimeters of the oil is injected after one determines that the patient can tolerate the treatment. At the following treatment, which may be 5 or 6 days later, larger amounts can be used. It may take 6 or 7 treatments to fill the cavity but one should always leave some space for the serous exudate which usually forms. If there is fever or irritating cough, it is not advisable to continue the treatment.

Postural drainage must be used in addition to oleothorax and other hygienic measures coincident with the oil treatment.

SUMMARY AND CONCLUSIONS

Such pity was aroused by the hopeless outlook of many patients before bronchiectasis was made a major study, that physicians and surgeons were stimulated to find something of benefit to these patients.

Bronchiectasis is still a serious disease which baffles the profession. The manifold character of the pathological process and the wide range of symptoms make it impossible to discuss the disease generally. Each type demands appropriate discussion and treatment.

In the diagnosis of these types, infinite care must be exercised to arrive at definite conclusions. Fortunately our methods of roentgenographic examinations, our expert laboratory facilities, and our increased acumen in physical diagnosis have enabled us to sift out properly the bronchiectasis from the many pulmonary cases which formerly were usually classed as tuberculosis, abscess of the lung, or even malignancy. Probably the greatest strides thus far have been in finding suitable cases for surgical approach.

It has taken almost 20 years to have a fairly good idea of bronchiectasis, but now, with the increased interest, the next few years may even find a cure.

The careful study of the bacteriological flora has also contributed much to our knowledge of bronchiectasis. The suggestion of the use of neoarsphenamine has been based on these studies.

The detailed treatment of sinus infections along with other symptomatic treatments have also been helpful.

The use of postural drainage has kept many patients so well drained of their purulent secretions that complications have been kept down to the minimum.

The use of compression belts to give the abdominal muscles support and also to raise the diaphragm has been effective in reducing discomforts of coughing and also aiding in the expectoration.

Finally, the medical treatments, while not always effective, have improved the patient so frequently that he can stand surgical treatment.

REFERENCES

1. Berck, M., and Harris, W. The use of roentgen therapy in bronchiectasis. J. Am. M. Ass., 1937, 108: 517–522.
2. Graham, E., Singer, J. J., and Ballon, C. Surgical Diseases of the Chest. p. 162. Philadelphia: Lea and Febiger, 1935.
3. Pritchard, S. Medical treatment of chronic suppurative non-tuberculosis bronchopulmonary affections. Tr. Nat. Ass. Prev. Consumpt., 1927, pp. 222–225.
4. Singer, J. J. A simple method of introducing iodized oil into the lungs. J. Am. M. Ass., 1926, 87: 1258.
5. Smith, David T. Etiology of primary bronchiectasis. Arch. Surg., 1930, 21: 1173.
6. Stitt, H. L. Bronchial lavage. Weekly Bull. St. Louis M. Soc., 1932, 26: 246.
7. Wooding, C. E. Medical aspects of bronchial lavage. Weekly Bull. St. Louis M. Soc., 1932, 26: 249.
8. Yankauer, S. Cited by Stitt.

RESULTS OF REPEATED OPERATIONS UPON THE STOMACH ESPECIALLY FOR GASTROJEJUNAL ULCERS

PROFESSOR HANS FINSTERER, Vienna, Austria

MY experience is based upon 331 repeated stomach operations, 2,753 operations for the relief of benign gastric lesions of which 2,433 were resections. On only 39 occasions did I perform the previous operation. Table I indicates the primary operation.

Closure of a perforated ulcer is an emergency operation. An acute ulcer may heal after closure but a chronic ulcer almost never heals until it is resected. Gastro-enterostomy rarely leads to permanent cure. Zuckschwerdt and Eck report cures in only 21.5 per cent with the development of a gastrojejunal ulcer in 51 per cent. Personally I have for the past 20 years resorted to gastro-enterostomy only in those cases with severe pyloric stenosis in which resection of the perforated ulcer was impossible. To prevent the development of a gastrojejunal ulcer these patients are strongly urged to return in 3 months for a radical resection even though they be free from signs and symptoms.

Recently I found in a 38 year old patient, who 4 months previously had had a gastro-enterostomy performed in my hospital for a perforated duodenal ulcer with pyloric stenosis, a large gastrojejunal ulcer about to perforate into the transverse colon. Complete recovery followed the radical resection. Two other patients, who failed to report as requested, finally had to be operated upon for a gastrocolic fistula, despite the fact that one of them was completely symptom-free after the first operation.

The commonest preceding operation performed was a gastro-enterostomy, 190 cases. In 12 of these no ulcer could be demonstrated upon re-operating, only chronic gastritis with a hypertrophic pyloric stenosis. It is somewhat questionable whether they ever had an ulcer. In 4 patients with normal or reduced gastric acidity the gastro-enterostomy was closed and Finney's operation performed, that is, gastroduodenostomy with division of the pylorus. Eight patients, due to high acidity, required a resection of the pylorus and antrum according to Billroth I or Haberer.

In 23 cases the chronic ulcer still persisted, without, however, a gastrojejunal ulcer. Years ago when confronted with this type of case I resected the stomach with the duodenal ulcer 3 times, and 3 times resected the pylorus and antrum when extirpation of the ulcer was impossible, not disturbing the previous gastro-enterostomy. Due to inadequate resection none of these were cured. So for the past 20 years I have been closing the gastro-enterostomy and after resection of two-thirds of the stomach do an end-to-side anastomosis between the jejunum and the remaining portion of the stomach according to the Hofmeister-Finsterer technique. All of these patients have been permanently cured.

In 155 cases a gastrojejunal ulcer had formed though often the old ulcer had healed. The patients developed signs and symptoms of the new ulcer soon after the gastro-enterostomy was performed. They had received medical treatment for long periods without relief, one case for 27 years, and another for 30 years with repeated hemorrhages.

In 8 cases of resection for exclusion of an unresectable duodenal ulcer, a planned 2-stage resection was done, removing the diseased gallbladder and excluding part of the antrum with the pylorus at the second stage. This latter was comparatively easy because the penetrating ulcer had already healed with a stenotic scar. Of the 9 cases in which a gastrojejunal ulcer developed after resection for exclusion, I had performed the first operation in 4 instances. The cause of the return in 3 of these was inadequate gastric resection. From 1919 to 1920, I resected only the antrum. The fourth patient, because of complications with cholelithiasis, was advised to return in 6 weeks for the second operation in order to prevent the formation of a gastrojejunal ulcer. The

From the First Surgical Section of the Allgemeines Krankenhaus.

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

patient, bleeding from such an ulcer, returned not in 6 weeks but in a year.

Of 44 patients, whose symptoms returned after gastric resection, only 5 were previously operated upon by me, 3 with the Billroth I, and 2 with the Hofmeister-Finsterer technique. It is interesting to note that there were 12 patients who had been operated upon by Lorenz who always did a Billroth II, resecting only the antrum.

Of 19 cases with a previous radical operation for gastrojejunal ulcer 10 had a Y-shaped anastomosis according to Roux and 4 an entero-anastomosis which favors the development of a gastrojejunal ulcer. Three patients, upon whom I had previously performed a Billroth I, later required a resection for a recurrent duodenal ulcer.

Repeated gastric operations are technically difficult due often to the many adhesions present. They are, therefore, attended with a higher mortality than ordinary. Of 331 patients operated upon, 39 died, or 11.7 per cent. By subtracting those cases complicated by acute perforation, acute hemorrhage, or gastrocolic fistula, the mortality rate drops to 8.6 per cent; or 299 cases with 26 deaths. Excision or closure of a perforated ulcer, pyloroplasty, sleeve resection of the stomach, or gastroenterostomy without gastrojejunal ulcer, do not present unusual difficulties at the time of re-operation. In only 2 of 83 resections did the patient die, a mortality of 2.7 per cent.

With the radical operation for gastrojejunal ulcer following a posterior gastro-enterostomy the mortality increased to 6.8 per cent, or 116 cases with 8 deaths. This increase is due partly to the procedure of Billroth I or Haberer, for it has been pointed out that in 28 cases 3 deaths were not due to the resection but rather to the technique of the anastomosis: (1) peritonitis due to leakage through the line of suture; (2) acute pancreatitis caused by reflux of the duodenal content into the pancreatic duct, due to the temporary stenosis of the end-to-end anastomosis of the jejunum;

TABLE I.—PREVIOUS OPERATION

	Cases
Closing of perforation	29
Closing of perforation and gastro-enterostomy	22
Jejunostomy	2
Pyloroplasty	3
Excision of the ulcer	7
Gastroduodenostomy	2
Gastro-enterostomy	168
Eiselsberg's pyloric exclusion	14
Sleeve resection	4
Resection for exclusion	17
Partial gastrectomy with removal of the ulcer	44
Radical operation for gastrojejunal ulcer	19
Total	331

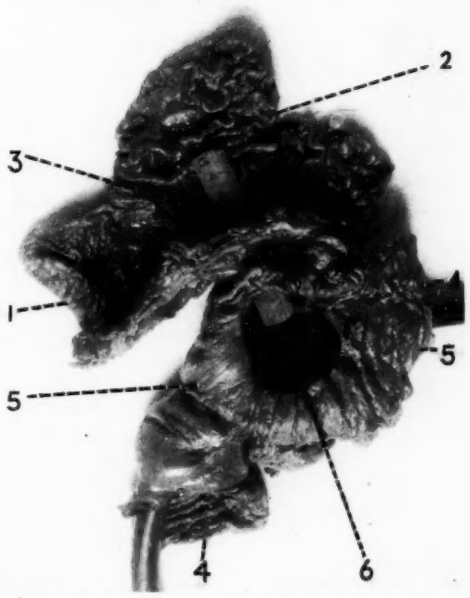


Fig. 1. Gastrojejunocolic fistula. *1*, Duodenum; *2*, lesser curvature; *3*, gastro-enterostomy; *4*, anastomotic loop with an introduced rubber tube; *5*, resected part of the transverse colon; *6*, opening of the fistula in the transverse colon.

TABLE II.—MORTALITY OF RADICAL OPERATION FOR UNCOMPLICATED GASTROJEJUNAL ULCERS

	Number	Mortality	Per cent
Previous operation			
Posterior gastro-enterostomy	116	8	6.8*
Anterior gastro-enterostomy	19	3	15.7
Eiselsberg's pyloric exclusion	13	2	15.3
Resection for exclusion	5	1	20.0*
Partial gastrectomy with removal of the ulcer	29	7	24.1
Radical operation for gastrojejunal ulcer	14	3	21.4
Total	196	24	12.2

*Mortality rate following radical operations for gastrojejunal ulcer after gastro-enterostomy is 8.1 per cent; after resection, 23.5 per cent.

and (3) death from toxemia due to occlusion of the end-to-end anastomosis of the jejunum. Therefore, the mortality is but 5.6 per cent, or 5 deaths in 88 cases when the radical operation for gastrojejunal ulcer after posterior gastro-enterostomy is performed according to the Hofmeister-Finsterer technique.

The radical operation for recurrent ulcer following gastric resection has a marked higher mortality. Seven patients with recurrent duodenal ulcer following a Billroth I, and 3 with gastritis following a Billroth II, all without a gastrojejunal ulcer, were cured by a more completely radical procedure. However, radical surgery for gastrojejunal ulcer following resection was attended with a mortality of 23.5 per cent or 8 deaths in 34 patients so treated.

Of these 8, 4 required a general anesthetic, 2 ether, one 220, another 250 cubic centimeters, and 2 nitrous oxide to supplement the local anesthesia. Two patients died of sepsis following an esophageal fistula and a left-sided subphrenic abscess; 1 died of heart failure; and 1 died with carcinoma of the pancreas diagnosed at the time of operation and confirmed at autopsy. One patient, in whom difficulty was encountered when the mesocolon was sutured to the anterior wall of the stomach, vomited so strenuously after operation that he had to be re-operated upon twice. This patient finally died of pneumonia. Of the 2 deaths due to peritonitis, 1 patient had eventration of the small bowel for 9 hours before discovery and repair. This 46 year old patient had a large ventral hernia, following the 2 previous laparotomies, which could not be properly repaired at the time of the third operation. The second death from peritonitis was due to infection, not, however, due to failure of the suture line.

The significant difference in the mortality rate following radical operations for gastrojejunal ulcer after gastro-enterostomy, 8.1 per cent, and after resection, 23.5 per cent, should, I believe, determine the indications for the management of a recurrent ulcer. Although I never hesitate to advise operation for a gastrojejunal ulcer following a gastro-enterostomy in those cases in which the ulcer recurs after resection, I advise medical treatment first. If repeated courses of treatment fail, despite its danger, new surgical interference is indicated.

The radical operation for a recurrent gastrojejunal ulcer is attended with a higher mortality rate not only because it is more difficult to perform, but also because the patient, due to previous operations and prolonged illness, has often become a morphine addict. Of 14 such patients 3 died, a mortality of 21.4 per cent.

A 47 year old colleague of mine, who had had 3 operations, 2 gastro-enterostomies and 1 resection for a gastrojejunal ulcer, with a Y-shaped anastomosis, required further surgery to relieve the unendurable pain of a large penetrating gastrojejunal ulcer. This patient, a morphine addict, insisted upon a general anesthetic and 390 cubic centimeters of ether were administered. However, the local anesthesia reduced the amount that would otherwise have been necessary. Thirty-six hours after operation the patient died of cardiac failure despite the establishment of normal intestinal peristalsis.

A 29 year old patient, who also had had 3 previous operations, a gastro-enterostomy and 2 resections, with a Y-anastomosis, required surgical relief for a large penetrating ulcer. This patient died from peritonitis that developed not from seepage through the line of suture but from infection that developed as a result of the poor asepsis maintained in that operating room. The third death was due to necrosis of the wall of the stomach, for during the resection the left gastric and last branch of the gastro-epiploic arteries had to be ligated, and the diaphragmatic arteries failed to provide an adequate blood supply.

A gastrocolic fistula complicating a gastrojejunal ulcer has a grave prognosis, for the patient loses weight very rapidly and may die of inanition without surgical interference. However, if such a fistula is not opposite the opening of the gastro-enterostomy but is distal to it, the patient may live for many years because most of the intestinal contents will proceed through its normal course into the small bowel and not through the short circuit into the colon.

Six years ago I operated upon a 50 year old patient on whom the roentgenologist, Dr. Freud, 14 years previously had demonstrated the existence of a jejunocolic fistula following a gastro-enterostomy. Finally, after years of reasonable comfort, this patient sought relief for severe pains and repeated hemorrhages. A 2-fingers' width jejunocolic fistula was found in the distal loop of the jejunum 5 centimeters distal to the gastro-enterostomy where there was also a gastrojejunal ulcer. Following resection of the colon with side-to-side anastomosis, resection of the anastomic loop with end-to-side anastomosis, and resection of the duodenum and two-thirds of the stomach with anastomosis according to the Hofmeister-Finsterer technique, the patient completely recovered.

Gosset reports a similar case. The patient had a jejunocolic fistula of 5 years' standing

and finally developed a gastrojejunocolic fistula through the perforation of a second gastrojejunal ulcer.

To control inanition it is sufficient to divide the colon and anastomotic loop closing both openings. To cure the patient a radical operation must be performed later when his condition improves. If the patient's condition is satisfactory, the radical operation for jejunal ulcer can be performed immediately after separation and suture of the colon. Both methods have their disadvantages, namely, the excision of the edges of the fistula and the suturing of the same are possible only when the opening is not too large; and the new lines of suture are placed in infected tissue, which, covered with omentum, may form an abscess that can perforate into the free peritoneal cavity and cause death from peritonitis.

I had 2 deaths in 6 such cases of radical operation for gastrojejunal ulcer with suturing of the colon, one of which was really quite interesting.

A 43 year old innkeeper had had a posterior gastro-enterostomy performed 5 years previous for an acute perforated duodenal ulcer. In a short time after the operation he developed periodic pains and finally a profuse diarrhea. X-ray examination confirmed the existence of a gastrocolic fistula, and at operation a 2-fingers' width colic fistula was found with the walls of the colon infiltrated. The colon was separated from the stomach, the opening closed with 4 lines of sutures and covered with omentum; then two-thirds of the stomach with the anastomotic loop were resected and the duodenum closed blindly. An end-to-end anastomosis of the jejunum, and distally to this an end-to-side anastomosis were done according to the Hofmeister-Finsterer technique. Finally a drain was placed under the liver. At first the patient established normal peristalsis despite continuous fever suggestive of pneumonia. Suddenly on the sixteenth day he developed terrific pains on the left side of his abdomen similar to those of a perforation. Upon reopening the abdomen 5 hours later an abscess was found near the colon repair, although the suture line was intact. The peritoneal cavity and the abscess were irrigated with normal salt solution and drained. The patient expired 3 days later from spreading peritonitis. In this case it was a mistake to repair the colon without resection, a mistake to cover it with omentum, and a mistake not to extraperitonealize and not to drain. It was impossible to save the patient after the abscess ruptured.

Thirteen patients required a radical operation for gastrojejunal ulcer and a resection of the colon. Seven of them had a 1-stage colon resection with side-to-side anastomosis and 3 of these died.

TABLE III.—MORTALITY WITH COMPLICATED GASTROJEJUNAL ULCERS

	Number	Mortality
Gastrocolic fistula		
Radical operation for gastrojejunal ulcer and closing of the colon	6	2
Radical operation for gastrojejunal ulcer and one stage colon resection	7	3
Radical operation for gastrojejunal ulcer and two stage colon resection	6	2
Total	19	7*

*Representing a total of 36.8 per cent.

	Number	Mortality
Acute profuse hemorrhage		
Immediate operation (24 to 48 hours)	5	..
Delayed operation (3 to 7 days)	6	4
Total	11	4*

*Representing a total of 36.3 per cent.

A 63 year old man, who had been sign and symptom-free for 17 years after a gastro-enterostomy, suddenly developed a profuse diarrhea lasting 3 weeks. During the radical operation, while mobilizing the short afferent loop, the gastrojejunal ulcer perforated, infecting the operative field. Peritonitis and death followed. In a second case the peritonitis developed not as a complication of the operation or from leakage from the suture line, but from the inadequate asepsis of an unsatisfactory operating room, which manifested itself in less serious cases. The third death could have been prevented for it was a mistake to perform a one-stage resection of a colon filled with feces.

A 43 year old man, with a gastric history of 20 years' standing, 2 severe hemorrhages, a gastro-enterostomy performed 10 years previously with recurrence of periodic pains within 2 years, profuse diarrhea for 2 months and a loss of weight of 30 kilograms, presented a gastrocolic fistula. At the operation, performed on May 2, 1935, under splanchnic anesthesia, a posterior gastro-enterostomy with a large gastrojejunal ulcer, a 3-fingers' width colic fistula with proximal stenosis of the colon were found, and the ascending and transverse colon was filled with feces. With a side-to-side anastomosis, 10 centimeters of the colon were resected. Resection of the duodenum and three-fourths of the stomach with the anastomotic loop, an end-to-end anastomosis in the jejunum, closure of the duodenum, and an anterior gastro-enterostomy with entero-anastomosis were performed because of the resection of the colon. The abdomen was then closed. On the first postoperative day the pulse was 84, on the second 88 and on the

third, because peristalsis failed to establish itself, a Witzel fistula was made in the cecum to relieve pressure on the sutures in the colon. Through this the bowel emptied itself, but infection developed in the abdominal wall and after a continuous high temperature for 7 weeks the patient expired due to chronic sepsis.

The 2 stage colon resection is indicated in those individuals in whom simple closure of the fistula is impossible due to its size and to surrounding infected areas. With such a procedure one can achieve fine results. The following case history is an example of this procedure:

A 61 year old man was sent to me from Jugoslavia with a gastric history of 14 years. He had had 3 severe hemorrhages, a gastro-enterostomy 3 years previously followed by recurrence of periodic pain, and since then 5 profuse hemorrhages, severe diarrhea for 3 weeks, and fecal vomiting for 2 weeks, accompanied by rapid loss of more than 20 kilograms in weight. An x-ray diagnosis showed a gastrocolic fistula. The patient was emaciated, weighing but 40 kilograms although he was 175 centimeters tall. He was severely anemic; 2,500,000 red blood cells, hemoglobin 40 per cent; and pulse 120. The operation was performed September 25, 1936, with splanchnic anesthesia, 70 cubic centimeters of one-fourth per cent novocain being used. Many adhesions were found. There was a posterior gastro-enterostomy with an entero-anastomosis where an ulcer-tumor, the size of a man's fist, had broken through the transverse colon. The duodenal ulcer had healed. The duodenum, two-thirds of the stomach with the anastomotic loop, and the entero-anastomosis were resected. The duodenum was closed, the jejunum united with an end-to-end anastomosis; and distally to this an end-to-side anastomosis with the remaining part of the stomach was performed. The transverse colon was resected, the distal end being closed and the proximal end sewed into the lower end of the incision as an artificial anus. The postoperative course was smooth. The specimen (Fig. 1) showed a very large opening, 5 centimeters in diameter, in the transverse colon opposite a very small gastro-enterostomy opening. The proximal jejunal loop was dilated and the proximal portion of the transverse colon was stenosed. Convalescence was rapid with recovery of loss of weight. Six weeks later after mobilizing the splenic and hepatic flexures the colon was united with side-to-side anastomosis. From this the patient recovered quickly, regaining all weight loss. On July 20, 1938, this patient was entirely well.

Of 6 patients with a 2 stage colon resection, 2 died.

A 39 year old man died on the fifth postoperative day from peritonitis, but the autopsy showed no leakage through the anastomosis. A 58 year old patient with recurrent gastrojejunal ulcer died on the eleventh postoperative day with broncho-pneumonia due to severe chronic bronchitis. The autopsy revealed no pathological change in the abdomen.

Gastrojejunocolon resection is attended with a high mortality. In 1931, Gosset had collected from the literature reports of 28 cases with 12 deaths a mortality of 42.8 per cent. Since 1931, 1 case each was reported by Hoffmann, McLean, and Verebely, 1 of which recovered. My own records show the same high mortality, 13 cases with 5 deaths. Perhaps the results can be improved with the 2 stage resection of Wilkie in which, at the first stage only, the fistulous tract is completely excluded and the colon reunited. Through this the danger of inanition can be avoided. After the patient has recovered sufficiently, the stomach, loop of the jejunum, and the excluded part of the colon can be resected in the usual manner, so that the danger of peritonitis, due to the separation of the colon and its closure, can be avoided altogether.

Prognosis in acute profuse hemorrhage depends upon the time of the operation. Even in severe cases the results are good, provided that operative treatment can be started within 24 to 48 hours without first attempting medical therapy. All of 5 such patients operated upon were cured. In 1 of these only the bleeding ulcer was excised, and in 4 a radical operation was performed. In 1 of these patients, a 40 year old man, the middle colic artery was eroded in the base of the penetrating ulcer.

With delayed operations that were performed after the third to the tenth day, because the hemorrhages persisted despite medical treatment and repeated transfusions, the results were not good. Of 6 such cases, 4 patients died. However, the death of 1 of the latter was due neither to hemorrhage nor to operation but to sepsis from a gangrenous appendix.

A 44 year old man gave a history of a pyloric and gastric resection 19 years previously after which there was a prompt return of his pains. He had had repeated courses of medical therapy with periods of improvement. Four severe hemorrhages occurred which were accompanied by fainting spells, the last hemorrhage taking place 4 days previous to admission. Hemorrhage recurred despite special medical treatment. The patient was operated upon for a

progressive anemia, 2,500,000 red blood cells, hemoglobin 30 per cent, pulse 120, soft, on January 31, 1930. There was a large stump of stomach left after a Billroth II, the small and large intestines were filled with blood, and a callous gastrojejunal ulcer was present at the site of the gastro-enterostomy opening. The stump of the stomach and the jejunal loop were resected. The jejunum was united with an end-to-end anastomosis, and an end-to-side anastomosis was performed with the small stomach stump. The abdomen was then closed. The immediate course was good. The pulse on the second day was 80 and there were no pains. In the evening pains developed in the right lower abdomen with a temperature of 39 degrees centigrade, pulse 128. On the third day the pain was localized over the appendix. Fair results were obtained by enema. Consent to operate was refused by the patient upon advice from the internist. On the fourth day the pains extended anteriorly, temperature rose to 39.5 degrees centigrade, pulse 120, and the patient consented to the operation. A lateral incision evacuated a putrid hemorrhagic exudate from the retroperitoneal space. The appendix, retrocecal and gangrenous, could not be removed without opening the peritoneum. Drainage was resorted to, and bacteriological examination revealed streptococci, which accounted for the serum. In due time a septic diarrhea appeared and persisted for 5 days when the patient died.

In a 27 year old man, operated upon during the war, was found an erosion of the middle colic artery, that had developed on the tenth day of the hemorrhage. Despite severe anemia, pulse 146 palpable only over the carotid, the patient had been given 0.02 grains of morphine in the medical ward. During the operation, which consisted of ligature of the middle colic artery, excision of the anastomotic loop with the ulcer, extraperitonealization of the colon for the 2 stage operation, he repeatedly stopped breathing, because of paralysis of the respiratory center from the severe anemia and the morphine. The pulse remained 146, palpable only over the carotid. At the conclusion of the operation, respiration again stopped for which artificial resuscitation was continued for 1½ hours at which time the heart stopped.

In a third and fourth case of radical operation patients died from peritonitis and pneumonia. It is questionable whether these 2 deaths could have been prevented by doing only a simple operation, namely, excision of the bleeding ulcer. A transfusion might have saved them but due to the circumstances a transfusion was impossible.

The acute perforation of a gastrojejunal ulcer is a rare but serious complication which can be cured only by operating promptly. I have observed only 2 such cases.

One of these was a 78 year old man upon whom 28 years previously a surgeon had performed a gastroenterostomy for a duodenal ulcer. Despite the constant diet observed, this man had periodic pain. Suddenly he developed a severe gastric hemorrhage followed by a perforation 12 hours later. Eight hours later, with diffuse peritonitis present, the abdomen was opened under local anesthesia and evipan. Due to its size, closure of the ulcer was impossible. Therefore, the gastro-enterostomy was discontinued, the stomach closed, the ulcer excised from the jejunal loop, and the jejunum reunited with end-to-side anastomosis. The old duodenal ulcer was healed so that normal anatomic relations were restored, and the peritoneal cavity was irrigated with normal salt solution. The immediate response was good with normal peristalsis established. However, on the 5th day the patient developed a cerebral hemorrhage from which he died 24 hours later.

The radical operation for gastrojejunal ulcer, and especially for gastrocolic fistula, is so serious, that one must give the type of anesthesia careful consideration. More than 15 years ago I pointed out in my monograph that the reduction in the mortality rate of major abdominal surgery, performed under local anesthesia, justifies its serious consideration. Today, based upon more than 6,000 laparotomies performed under different types of local anesthesia, I can corroborate that statement. By precluding deep ether anesthesia, one can prevent those deaths that, commonly ascribed to operative shock, are really due to the after-effects of protracted anesthesia upon the parenchymatous organs. Because the normal resistance of peritoneum and lung, otherwise affected by general anesthesia, are not disturbed by local anesthesia, a marked reduction in the number of deaths due to peritonitis and pneumonia can be effected. This is shown so well by the radical operation for gastrojejunal ulcer.

TABLE IV.—ANESTHESIA IN UNCOMPLICATED CASES

	Number	Mortality	Per cent
General narcosis	19	8	42.1
Local mesenteric and splanchnic	177	16	9.0
Total	196	24	12.2

In 19 cases the operation was started under general anesthesia solely, upon the insistent demand of the patient who was really otherwise physically fit. Immediately after induction, the general anesthetic was supported by local infiltration of the abdominal wall and

mesentery in order to block the field of operation and so to prevent the operative shock described by Crile in his well-known book, *Surgical Shock and Shockless Operations through Anoci-Association*, and also to reduce the amount of ether and nitrous oxide required. Ordinarily, with such a procedure only 180 to 390 cubic centimeters of open ether were required. Of these 19 patients 8 died, a mortality of 42.1 per cent.

In 3 instances the cause of death was an infection, peritonitis, and subphrenic abscess. In a fourth, reopening the abdomen revealed an obstruction high in the small bowel due to an adhesion of the bowel with a hematoma that had developed after operation. A 36 year old man who had to have a radical operation for a gastrojejunal ulcer following resection, presented many adhesions about the proximal jejunal loops which had to be separated. Three days later, when the wound had to be reopened for continuous vomiting, only fresh adhesions were found and no peritonitis. The patient expired 3 hours after operation. There was no autopsy.

In 3 cases death could be accounted for by the general anesthetic.

A 58 year old man who insisted upon a general anesthetic, and who had 120 cubic centimeters of open ether and 200 cubic centimeters of closed ether, died suddenly 1 hour after the conclusion of the operation. Autopsy showed a thrombosis in the right coronary artery. A 47 year old colleague who was given 390 cubic centimeters of open ether in addition to the local anesthetic, died 36 hours after operation of cardiac failure, despite the fact that normal peristalsis had already re-established itself. A 52 year old man given 300 cubic centimeters of open ether to support local anesthesia for a radical operation showed typical postanesthetic gastro-intestinal atony, that is continuous vomiting, yet normal bowel movements. Intervention on the fourth day showed the stomach stump and proximal jejunal loop, 1½ meters, to be greatly dilated and paretic, with the remaining small bowel showing normal peristalsis without any adhesions.

I have observed this atony 5 times in 700 laparotomies performed under a general anesthetic probably due to a paralysis of an innervation center for the stomach and upper part of the jejunum, and yet have never encountered such atony in over 6,000 operations performed under local anesthesia.

Of 209 operations performed under local anesthesia, 155 required no general anesthetic whatsoever, while 54 required slight support with open ether, 30 to 50 cubic centimeters, and at no time exceeding 150 cubic centimeters during the entire procedure. Of these 29 died, or 14.1 per cent. By subtracting 32 cases complicated with acute profuse hemorrhage, acute perforation, and gastrocolic fistula, the correct mortality rate for radical operation under local anesthesia is only 9 per cent or 177 cases with 16 deaths. None of these died within the first 5 days of so called operative shock, and only 1 died with pneumonia.

A 70 year old man presented the following history: A gastro-enterostomy had been performed 30 years prior to admission but his periodic pains returned together with repeated hemorrhages. Two months before frequent vomiting occurred and he had suffered a loss of 30 kilograms in weight. The laparotomy under splanchnic anesthesia, using one-fourth per cent novocain, revealed a duodenal ulcer penetrating into the pancreas, a large gastrojejunal ulcer penetrating into pancreas and mesocolon, and about to perforate into the transverse colon. The duodenum was resected without excising the base of the ulcer and the duodenum was closed. The gastro-enterostomy loop was separated from the base of the ulcer which measured 5 by 3 by 2 centimeters. Resection of two-thirds of the stomach with the anastomotic loop was performed; and an end-to-end anastomosis of the jejunum, distally to which an end-to-side anastomosis according to the Hofmeister-Finsterer technique was done. The base of the ulcers was drained. There were no postoperative abdominal complications; however, the patient died 1 week later with bilateral bronchopneumonia which developed because he was too feeble to raise the sputum accumulating from his severe chronic bronchitis.

Three deaths, caused by peritonitis from leakage through the line of sutures, high intestinal obstruction through occlusion of the end-to-end anastomosis of the jejunum, and acute pancreatitis, can be accounted for by the technique employed, either Billroth I or Haberer's modification of it. Two patients died with a subphrenic abscess and a gastric fistula. Of 7 deaths due to peritonitis 3 could have been avoided. One was caused by prolapse of the bowels due to a large inoperable ventral hernia; another was due to perforation of the anterior wall of the stomach induced by the cutting through of a poorly placed fixation suture of the mesocolon slit; and another was the consequence of necrosis in the posterior wall of the stomach. Four deaths resulted from peritonitis that developed as a result of

the poor asepsis maintained in various hospitals. One death due to volvulus of the sigmoid had no connection whatever with the operation.

The radical operation for gastrojejunal ulcer is attended with a high mortality rate not only because the operation is difficult to perform, but also because the patient so often is first operated upon after the appearance of complications. Alessandri reports a 15.3 per cent mortality; Zuckschwerdt and Eck of Enderlin's Clinic, 14.2 per cent; Oglivie, 19 per cent; and Walton, 25 per cent. Luff reports a 33 per cent mortality rate from cases collected by the British Medical Association.

My records show a mortality rate of 16.2 per cent. By subtracting the 32 cases complicated with acute hemorrhage, perforation, and gastrocolic fistula, the correct mortality rate drops to 12.2 per cent, that is, 24 deaths from 196 radical operations. Despite the fact that the mortality rate rises with the age of the patient, nevertheless, the results obtained with patients over 60 years of age are not so unfavorable as to hinder one from performing radical surgery for that reason alone, as has so often been claimed. As is apparent from Table V, of 14 patients, 60 to 73 years of age, 3 died, making a mortality rate of 21.4 per cent, but only 1 death could be attributed to the advanced age and cachexia, and that was a 70 year old man who died 1 week after operation with pneumonia. The second was a 65 year old man who died with peritonitis that had developed from the base of the penetrating ulcer, which was really the mucous membrane of the colon. The third patient died from volvulus of the sigmoid which had had no bearing upon the operation. To achieve such results it is necessary not only to avoid the use of a general anesthetic but also to institute proper postoperative care; pantopon and morphine should be omitted altogether, because these reduce the coughing reflex and increase the difficulty of expectorating. Older patients with restricted thoracic expansion must be helped to expectorate by rhythmic compression of the thorax.

The mortality of 12.2 per cent in my own records could have been markedly improved because in 9 instances death could have been avoided. These deaths were the results of the following cases: 3 were due to general anesthesia; 3 to the use of the method of Billroth I, or Haberer's modification; 1 was due to the poorly placed fixation suture of the mesocolon slit; 1 was the result of leakage from the end-to-end anastomosis of the jejunum, which occurred because the afferent loop of the end-to-side anastomosis was so short that it pulled constantly on the proximally located end-to-end anastomosis; and finally 1 case was due to prolapse of the bowel through the abdominal wound which broke down because of an inoperable ventral hernia and vomiting, which easily could have been avoided by a properly applied abdominal binder. The 4 deaths from peritonitis due to infection from without also could have been avoided had it been possible to perform all the operations in one reliable institution instead of in 9 different hospitals. So, the mortality rate of radical operations performed under local anesthesia could be reduced to 4 per cent without selecting cases, which is, after all, the mortality rate of primary ulcer resection.

TABLE V.—AGE OF UNCOMPLICATED CASES

Age in years	Number	Mortality	Per cent
22–29	20	2	10.0
30–39	57	3	5.2
40–49	72	10	13.8
50–59	33	6	18.1
60–69	11	2	18.1
70–73	3	1	33.3
Total	196	24	12.2

Of greatest importance are the permanent results achieved by repeated gastric operations. What procedure should be adopted to prevent a recurrence? Is it possible to cure these patients permanently through repeated operations, or are they to be classified as surgically incurable due to a marked disposition toward developing recurrent ulcers? The answer to these questions could be learned only by subsequent re-examination, or at least from reports submitted by the patient. In those cases, lacking a follow-up report, can be included some who failed to reply, because they were either disappointed with end-results, or had even submitted to further surgery by some one else. Therefore, every statistical report including more than 10 per cent of such

TABLE VI.—END-RESULTS OF RADICAL OPERATIONS PERFORMED 1912–1935

Type of operation	No.	Cured No.	Cured Per cent	Improved No.	Improved Per cent	Unimproved No.	Unimproved Per cent
Billroth I.....	7	4	....	..	....	3	....
Haberer's modification of Billroth I.	22	17	77.2	3	13.6	2	9.0
Hofmeister-Finsterer's modification of Billroth II....	96	88	91.6	4	4.1*	4	4.1
Y-shaped anastomosis (Roux)...	21	7	33.3	1	4.7	13	61.9

*The total cured and improved according to the Hofmeister-Finsterer technique is 95.7 per cent.

cases is of little value. Because I failed to obtain follow-up reports in 6 of the 9 patients operated upon for gastrojejunal ulcer in the States, my statistics for "lost" cases has increased to 6.4 per cent.

Recurrence of a gastrojejunal ulcer after excision is inevitable due to failure to remove one or more of the causal factors. The separation of a gastro-enterostomy with closure of the stomach and the jejunum, thereby effecting restoration of normal anatomical relations, should be the method of choice according to Allen and Judd for the management of a gastrojejunal ulcer. This I do only when no gastrojejunal ulcer is present and moreover no ulcer probably ever was present. When a gastrojejunal ulcer is present the simple degastro-enterostomy will lead to recurrent duodenal ulcer. I performed a typical resection upon 5 patients for recurrent duodenal ulcer following a simple degastro-enterostomy for gastrojejunal ulcer which had been performed by other surgeons.

To prevent the recurrence of a gastrojejunal ulcer Baum and later Haberer advised the completion of the radical operation with a Billroth I. It is true that this will positively prevent the return of a gastrojejunal ulcer, but not the recurrence of a duodenal ulcer, because the resection simply cannot be as extensive as with the Billroth II or its modifications. Otherwise the tension on the suture lines leads to leakage, peritonitis, and death. According to the experimental work of Smidt, the removal of half of the stomach in the Billroth I may be sufficient because the entrance of the gastric content into the duodenum provokes a prompt reflex stimulus from Brunner's glands, which inhibits the production of hydrochloric acid in the fundus. This reflex cannot start with a Billroth II except that there may be a retrograde filling of the duodenum.

With the Billroth I, my experiences have been unsatisfactory. In my work with 8 cases, 1 patient failed to reply, 4 were cured, and 3 developed a recurrence of the duodenal ulcer as demonstrated at postmortem in 1 and reoperation in 2 cases. These latter were cured by a new extensive resection with anastomosis according to the Hofmeister-Finsterer technique. Horsley also reports 2 recurrences of duodenal ulcer after a Billroth I.

The end-to-side gastroduodenostomy, according to Haberer, leads to better permanent results, because the acid gastric content enters the duodenum opposite the papilla and is immediately neutralized. Of 24 cases, 2 patients failed to report and 17 are fully cured, 77.2 per cent; 3 patients were improved, 2 of whom had developed pulmonary tuberculosis and 1 cholecystitis, and 2 were unimproved, 9 per cent.

A 38 year old man was symptom-free for 6 years following a radical operation in 1928. Since 1934 he has had periodic pains, and once a black, tarry stool. A 37 year old man was symptom-free for 2 years after which he developed periodic pains, heartburn, and repeated small hemorrhages, and in May, 1938, he had a severe hemorrhage. X-ray examination then showed a callous gastric ulcer.

The best permanent results could be attained through the extensive resection of the stomach in which at least two-thirds to three-fourths of the stomach are removed, and an end-to-side anastomosis performed according to the Hofmeister-Finsterer technique. Of 96 patients 88 are permanently cured, or 91.6 per cent. These have no dietetic restrictions, have gained up to 30 kilograms in weight, and are fully able to work. Forty-one cases were operated upon 10 to 20 years ago, so that one can really consider them permanently cured. Four patients are improved for they have no pain; they do have occasional periods of anemia and 1 patient also has pulmonary tuberculosis. Four patients remain unimproved, or 4.1 per cent.

A 28 year old man in 1920 had a gastro-enterostomy for a perforated duodenal ulcer. In 1922, an excision

of the posterior gastro-enterostomy with the gastrojejunal ulcer was done and a new gastro-enterostomy created. At the third operation which I performed in November, 1923, at the Buffalo Sisters Hospital, 2 callous gastrojejunal ulcers, an old duodenal ulcer, and a marked dilated stomach were found. A follow-up report from Dr. Burke related that the patient was well until 1931 at which time the periodic pain had returned, and that in 1934 an acute perforation of a recurring gastrojejunal ulcer was closed. No further reports were available on this case.

A 39 year old man had 6 operations performed upon his stomach from 1930 to 1934 including 1 gastro-enterostomy and 2 resections by other surgeons. In February, 1934, a seventh operation was performed by myself for a recurrent gastrojejunal ulcer, i.e., a resection of the large stomach stump with the anastomotic loop, end-to-end anastomosis with the jejunum, and end-to-side anastomosis with the stomach. Because of kinking of the afferent loop an entero-anastomosis had to be added. Nevertheless, after this operation pain soon recurred despite repeated efforts with medical therapy. In April, 1935, I performed the eighth operation and found a large gastrojejunal ulcer penetrating to the mesocolon and transverse colon. My procedure in operating was the following: Resection of the anastomotic loop with entero-anastomosis and with so small a portion of the stomach as was technically necessary; end-to-end anastomosis of the jejunum; distally end-to-side anastomosis according to Hofmeister-Finsterer and cholecystectomy. The patient has remained completely recovered during the past 3½ years.

Two physicians, one 67 and one 68 years old, are dissatisfied with operative results. In the first case, pain was produced by a large ventral hernia of 14 years' duration, there were repeated attacks of chronic obstruction and symptoms of too small a stomach due to its slow emptying, which was a direct result of many adhesions. In the second case, the recurrence of the ulcer can be explained. The accompanying entero-anastomosis failed to neutralize the acid gastric content at the point of the gastro-enterostomy. Despite the fact that practically no further stomach resection was performed, the patient remained permanently cured.

Every entero-anastomosis favors the development of a gastrojejunal ulcer if the bile and duodenal content really pass through the entero-anastomosis. This is not always so, because neutralization of the gastric content at the point of the gastro-enterostomy is impossible. For this reason I include entero-anastomosis only when there is kinking of the afferent jejunal loop.

Roux's Y-shaped anastomosis led to poor permanent results. Of 21 patients only 7 were cured, 1 improved, while 13 or 61.9 per cent, remained unimproved. In 6 of these 13, the diagnosis of recurrent gastrojejunal ulcer was established upon re-operation, and in 7 the diagnosis was indicated by the recurrence of periodic pains, hemorrhage, and x-ray findings. If the gastric secretions have not become neutral, which does not always follow after resection of half of the stomach, and which almost never follows resection of the antrum, the gastrojejunal ulcer will recur after a Y-shaped anastomosis; because that part of the anastomotic loop between the gastro-enterostomy and the entero-anastomosis is exposed to the acid contents of the stomach which are first neutralized by bile and duodenal secretions at the entero-anastomosis. Only if the gastric secretions are neutral through extensive resection of the stomach, can one achieve a permanent cure with a Y-shaped anastomosis.

This is well illustrated by 2 patients, brothers, 42 and 44 years of age, upon whom I operated 19 years ago for gastrojejunal ulcers that developed after gastro-enterostomy. At this time only half of the dilated stomach with the pylorus and the anastomotic loop were removed, and a Y-anastomosis performed. After 6 weeks, pain, hemorrhage, and heartburn returned. Despite repeated efforts with medical therapy in various institutions there was no improvement. The pain finally became so severe that 6 grains of morphine administered every 24 hours failed to control it. At the third operation performed upon the brothers in 1921, a large recurrent gastrojejunal ulcer was found penetrating into the pancreas and mesentery of the anastomotic loop, and extending down to the junction with the afferent loop. At that time so large a part of the stomach and also of the Y-shaped anastomosis was resected that only about one-fifth of the normal stomach remained. A new Y-shaped anastomosis was performed. These patients recovered quickly, gaining 15 and 20 kilograms in weight, and have remained free from all symptoms for the past 17 years. Moreover, they observe no diet restrictions and are fully able to work.

I no longer employ the Y-shaped anastomosis, which I favored 15 years ago because it was somewhat easier to perform. The results obtained by it are poor. Moreover, 14 years ago I openly criticized this procedure which until recently was still practised by some surgeons. Lahey also criticizes this operation as a result of his unsatisfactory experiences.

Those patients, in whom gastrojejunal ulcer recurs after repeated operations upon the stomach, are often considered "surgically incurable." I have again and again asserted that those patients, classified by Mandl as "surgically incurable" after repeated operations upon the stomach, have never really had a gastric resection. Upon a patient so classified by Mandl a fourth operation, which was a typical resection of two-thirds of the stomach, actually resulted in a permanent cure. The cause of repeated recurrent ulcers is not an unusual disposition to develop ulcers which cannot be controlled surgically, but is the failure to do a sufficiently extensive resection of the stomach. as for example, resection of only the antrum, or a Y-shaped anastomosis, or an entero-anastomosis. This can be illustrated by the following case:

A 33 year old man had had 4 operations upon the stomach by 4 different surgeons; (1) a posterior gastro-enterostomy; (2) closure of the posterior gastro-enterostomy and the formation of an anterior gastro-enterostomy with an entero-anastomosis; (3) resection of the pylorus and antrum with the anastomotic loop, and an end-to-side anastomosis; and (4) a Y-shaped anastomosis, because of a recurrence of the gastrojejunal ulcer with stenosis, following which a gastrocolic fistula developed with a marked loss of 40 pounds in weight. At the fifth operation, performed under splanchnic anesthesia with one-fourth per cent novocain solution, it was found that the former ulcer at the end-to-side anastomosis had healed and a new ulcer had formed at the Y-shaped anastomosis which had perforated into the colon. In operating the following procedure was followed: Resection of the transverse colon; resection of the large stump of the stomach, lesser curvature 10 centimeters and greater curvature 15 centimeters with both anastomosis and the old entero-anastomosis; a side-to-side anastomosis of the transverse colon, an end-to-end anastomosis of the jejunum, and distally to this an end-to-side anastomosis with the stomach, according to Hofmeister-Finsterer. Recovery without complaints followed with a marked gain in weight of 20 kilograms. However, 4 years later this patient died with tuberculosis of the larynx and lung. The autopsy revealed no pathological lesion in the stomach.

My statistics show 8 instances wherein the patient had been operated upon 3 to 6 times without permanent success. Nevertheless, even these cases could be permanently cured by another more extensive gastric resection.

Balfour had 3 similar cases of repeated recurrent ulcer following resections, in whom the last operation of terminolateral gastroduodenostomy was attended with a permanent cure.

For the patient it is surely better to prevent a gastrojejunal ulcer with its high attendant mortality. This can be achieved if the gastroenterostomy is employed only in rare exceptional cases, and if, with the resection of the ulcer, or with my method of resection for exclusion of a non-removal duodenal ulcer, a very large part of the stomach is removed, so that permanent gastric anacidity is established. The removal of the antrum, i.e., the distal third of the stomach, which is still called an extensive gastric resection by many surgeons, is no guarantee of permanent cure. At least two-thirds of the stomach, and in cases with a marked dilatation of the stomach in which only the antrum is dilated three-fourths and more of the stomach must be removed, so that finally there remains only the normal cardiac third of the stomach. The resection can be considered adequate only when it continues to the point on the lesser curvature where the left gastric artery from the celiac axis comes to the stomach, and on the greater curvature to a point which is a hand's breadth to the left of its midpoint, recognizable by the absence of the arcade. Since 1918 I have recommended the two-thirds resection as a routine method, but in 1920 Haberer and Schmieden disagreed because they believed that this operation was too radical and that resection of the antrum was sufficient. In 1922, Hohlbaum called this procedure vandalism in the field of surgery. But experience has shown that my proposition, namely, that the most reliable permanent cure could be effected only by the extensive two-thirds resection of the stomach, was correct. With resection of the antrum, which I occasionally performed years ago, there was recurrence in 4 out of 28 patients so operated upon, 2 gastrojejunal ulcers, and 2 recurrent duodenal ulcers; while with the two-thirds gastric resection employed in the last 15 years with over 1,500 cases only 1 patient had to be re-operated upon for gastrojejunal ulcer. Recurrence follows upon failure to establish anacidity by sufficient extensive resection. In 28 patients with gastrojejunal ulcer after resection upon whom Friedemann had

to re-operate, he found 12 patients with hyperacidity, 12 patients with normal acidity, and 2 patients with hypoacidity, but not 1 patient with anacidity.

It is true that extensive resection has some disadvantages especially the complaints referable to a small stomach. In my experience this is present only in the early months, disappearing in more than 90 per cent of such patients with the gradual dilatation of the anastomotic loop. Nor is there much likelihood that either secondary or pernicious anemia will develop, although I have observed 2 of the latter. With modern liver therapy these can be controlled easily. When comparing the minor complaints with the dangers of a gastrojejunal ulcer, one cannot consider the former justifiable contra-indications against extensive resection. And until a more effective nonoperative treatment is found, extensive primary gastric resection is justified to avoid a gastrojejunal ulcer as much as possible.

CONCLUSIONS

A report of 331 repeated gastric operations with a mortality of 11.7 per cent is given. After those cases complicated by acute perforation, acute hemorrhage or gastrocolic fistula are subtracted, the mortality drops to 8.6 per cent.

The most frequently performed previous operation was gastro-enterostomy, 190 cases, after which either the old ulcer had not healed, or a gastrojejunal ulcer had formed. Therefore, I consider gastro-enterostomy an operation to be performed only in rare, exceptional instances.

The radical operation for a gastrojejunal ulcer, following posterior gastro-enterostomy, shows a lower mortality, 6.8 per cent, than when it follows resection, 23.5 per cent. Therefore, an operation is indicated at once by the return of complaints in a patient after gastro-enterostomy; and it is to be delayed, if the complaints return after resection until at least several attempts with medical therapy have been made. The mortality rate attending the radical operation for recurrent gastrojejunal ulcer is 21.4 per cent.

The radical operation for a gastrocolic fistula has a higher mortality rate even if the colon is only separated and closed. The danger lies in the unreliability of the colon sutures, due to the surrounding inflamed area, 6 cases with 2 deaths. The high mortality of 5 deaths out of 13 cases for resection of the stomach and colon can be reduced by performing a 2 stage resection of the colon.

In a case of acute profuse hemorrhage from a gastrojejunal ulcer, the radical operation performed immediately is attended with good results. I had 5 such patients and all were cured. If performed late after unsuccessful medical treatment, it is attended with poor results, for of 6 such patients, 4 died. Therefore, early surgical intervention should be instituted promptly.

In acute perforation even the lesser operation, either closure or excision of the ulcer, produces poor results.

The mortality rate attending the radical operation for gastrojejunal ulcer depends also upon the type of anesthetic employed. The radical operation under general anesthetic, ether or nitrous oxide, was performed rarely and only in uncomplicated cases, when the patients were young and strong and insisted upon it. Radical operation for gastrojejunal ulcer showed a mortality rate of 42.1 per cent, or 19 cases with 8 deaths. Of these, 3 deaths were directly attributable to the anesthetic. With local anesthesia, splanchnic anesthesia, the mortality rate was 14.1 per cent, or 209 cases with 29 deaths; and by subtracting the 32 cases complicated by acute hemorrhage, perforation, or gastrocolic fistula, the correct mortality rate is 9 per cent. There was not a single death after operation due to so called operative shock and only 1 death due to pneumonia, despite the fact that 14 patients ranged from 60 to 78 years of age.

The best permanent results are achieved with the extensive two-thirds to three-fourths resection of the stomach and the preparation of the end-to-side anastomosis according to Hofmeister-Finsterer, even though there may have been several preceding operations. Of 96 cases 88 are permanently cured, or 91.6 per cent.

With the Billroth I the end-results are not as good, 4 cases cured, 3 cases unimproved. With terminolateral gastroduodenostomy of

Haberer 17 cases were cured, 77.2 per cent; 3 improved, 2 unimproved, 9 per cent. In both of these methods a less extensive gastric resection was performed.

With Roux's Y-shaped anastomosis permanent results are the poorest, 7 cases cured, 1 case improved, 13 cases unimproved, or 61.9 per cent. There also the two-thirds resection of the stomach was inadequate, for a permanent cure is possible only if the gastric juices remain absolutely anacid.

The recurrence of a gastrojejunal ulcer after radical operation is not due to special ulcer disposition but to technical faults, too limited resection, Y-shaped anastomosis, or enteroanastomosis. Therefore, by avoiding these errors in technique, permanent cure is possible even after repeated resections. The term, "surgically incurable ulcer," is not applicable to this type of case.

The number of gastrojejunal ulcers can be diminished if the gastro-enterostomy is employed in only rare and exceptional cases, and if with the resection of the ulcer and with the resection for exclusion of unremovable duodenal ulcer, not just the antrum, the distal third of the stomach, but at least two-thirds of the stomach; and in those instances with marked dilatation even three-fourths are removed, so that only the normal cardiac third remains. The disadvantages of extensive gastric resection, too small a stomach and anemia, are of little consequence, since they are more easily controlled than a gastrojejunal ulcer following inadequate gastric resection.

We especially wish to express our appreciation to Dr. Burwig, Buffalo, New York, for his translation of this paper from German into English.

BIBLIOGRAPHY

1. Alessandri. Zentralbl. f. Chir., 1937, p. 1394.
2. Allen. Am. J. Surg., 1928, 5: 128.
3. Balfour. Ann. Surg., 1931, 94: 489.
4. Baum. Zentralbl. f. Chir., 1921, p. 586.
5. Crile and Lower. Surgical Shock and the Shockless Operation through Anoci-Association. Philadelphia: W. B. Saunders Co., 1921.
6. Finsterer. Zentralbl. f. Chir., 1918, p. 434. Arch. f. Chir., 1924, 133: 581; 1937, 189: 597. Local Anesthesia Methods and Results in Abdominal Surgery. New York: Rebman Co., 1923.
7. Freud. Berl. klin. Wchnschr., 1918, p. 1021.
8. Friedemann. Zentralbl. f. Chir., 1937, p. 2571.
9. Gosset. Congrès franç. de chir., 1931, p. 31.
10. Haberer. Arch. f. klin. Chir., 1921, 117: 56.
11. Hoffmann. Zentralbl. f. Chir., 1932, p. 917.
12. Horsley. Ann. Surg., 1931, 94: 490.
13. Judd and Hoerner. Ann. Surg., 1935, 102: 1003.
14. Luff. Brit. M. J., 1929, 2: 1074.
15. Mandl. Deutsche Ztschr. f. Chir., 1920, 156: 167.
16. McLean. Beitr. z. klin. Chir., 1932, 155: 525.
17. Ogilvie. Lancet, Lond., 1935, p. 419.
18. Smidt. Arch. f. klin. Chir., 1923, 125: 26; 1924, 130: 307.
19. v. Verebely. Arch. f. klin. Chir., 1936, 187: 468.
20. Walton. Brit. J. Surg., 1934, 22: 33.
21. Wilkie. Ann. Surg., 1934, 99: 401.
22. Zuckschwerdt and Eck. Deutsche Ztschr. f. Chir., 1933, 236: 424.

RECURRENT HYPERTHYROIDISM

A Report of 306 Cases Operated upon from 1928 to 1937

RICHARD B. CATTELL, M.D., F.A.C.S., and EDWARD S. MORGAN, M.D.,
Boston, Massachusetts

RECURRENCE or persistence of the symptoms of hyperthyroidism following surgical treatment is sufficiently frequent to demand our attention. Subtotal thyroidectomy is recognized as the most effective means of relieving the symptoms of hyperthyroidism as 90 to 95 per cent of patients obtain satisfactory results. In the small group of unrelieved patients the largest number of unsatisfactory results are due to the recurrence of symptoms. In spite of the large number of reports in the literature dealing with the surgical treatment of hyperthyroidism, there have been relatively few which have concerned themselves primarily with the problem of recurrent and persistent hyperthyroidism. Lahey and Clute (11), Thompson, Morris and Thompson, Jackson, Pemberton, Else, Crile, and more recently Gillette and Scott have presented the incidence, means of prevention, and treatment. In a previous report from this clinic, Lahey and Clute (11) reported 48 cases up to 1926. It is the purpose of this study to present the factors responsible for the persistence or recurrence of symptoms following operation, outlining the management of these cases at the Lahey Clinic during a 10 year period from 1928 to 1937 inclusive. During this time 306 patients were operated upon for this condition and an additional small group were treated medically.

DIAGNOSIS

The diagnosis of recurrent and persistent hyperthyroidism presents the identical problem as does the disease in its original form, and for this reason it is unnecessary to discuss this aspect in detail. With their previous experience these patients are likely to recognize the fact that they have had a recurrence of their trouble. In the milder cases, nervousness, persistent tachycardia, and palpitation are common complaints. Weight loss in spite of adequate food intake and inability to carry out a normal activity, without exaggeration of symptoms, make one suspicious of a return of the hyperthyroidism. A return of the eye signs, particularly stare and exophthalmos, is present. It is important to realize that palpation of the thyroid remnants is unreliable. The scar tissue resulting from the previous subtotal thyroidectomy makes it difficult to outline the lateral thyroid lobes. For this reason particular emphasis should be placed on the patient's story rather than on the examination of the gland. The diagnosis will usually be established by determining the basal metabolic rate.

From the Department of Surgery, The Lahey Clinic.
Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

PERSISTENT AND RECURRENT HYPERTHYROIDISM

Patients presenting symptoms of hyperthyroidism following thyroidectomy should properly be divided into the two groups of persistent and recurrent hyperthyroidism. We consider that patients have persistent hyperthyroidism who have not been fully relieved of their symptoms following operation and who do not have a return of the basal metabolism to normal within a 6 month period. If the patient has been relieved of symptoms for an interval of 6 months or more and then has a return, he is considered to have recurrent hyperthyroidism. The division of the cases into these two groups seems important since they present different problems.

Persistent hyperthyroidism is due to the failure to remove sufficient thyroid gland at the original operation. This should properly imply an inadequate procedure and may be due to a number of factors. Dr. Lahey (13) has repeatedly emphasized the necessity of obtaining adequate exposure of the gland

and states that it is impossible to estimate the amount of thyroid tissue removed unless exposure is obtained. Failure to remove all of the superior pole or retrolaryngeal extension is a frequent cause. Failure to remove a pyramidal lobe may likewise result in a persistence of symptoms. A technique which leaves a portion of the isthmus over the trachea does not permit accurate appraisal of the amount of thyroid tissue left *in situ*. Too much thyroid tissue may be left in the usual lateral remnants because of the fear of injury to the recurrent nerve or parathyroid glands. In more recent years, when adequate subtotal thyroidectomy has been carried out, persistent hyperthyroidism has been much less frequent. With present day methods we can be less concerned with this condition.

Recurrent hyperthyroidism may occur in spite of apparently adequate subtotal thyroidectomy and may appear at any time following operation. The cause of recurrence is unknown and must be due to the same factors responsible for the original disease. Pemberton called attention to the fact that all recurrences cannot be related to the amount of tissue removed. Thompson et al., Jackson, Gillette, Lahey and Clute (11) have all stated that fewer recurrences would occur if sufficient thyroid tissue was removed at the first operation. Because of the frequency of recurrent hyperthyroidism its prevention should be attempted. The most important point emphasized by all authors is adequate subtotal thyroidectomy.

Jackson and Else reported that postoperative administration of iodine will prevent many cases. For a number of years we gave our patients 10 minims of Lugol's solution daily for 3 months following operation. In a later series and at the present time the administration of iodine is discontinued at the time of the patient's discharge from the hospital. A comparison of the recurrent rates in these two groups showed that the administration of iodine did not lower the incidence of recurrence in our cases (2). Brenizer stated that recurrences could not be prevented by iodine. The careful regulation of the lives of patients following subtotal thyroidectomy for a period of months or even a year does, we believe, lessen the number of patients having later symptoms. This regimen should require adequate periods of rest during this convalescent period, relief of mental and physical stress, absence from work for 6 weeks to 3 months, and the avoidance of stimulants such as alcohol, tobacco, coffee, and tea.

Although a number of authors have stated that the means mentioned have reduced recurrences, it has been impossible to ascertain which patients are likely to have a recurrence of their hyperthyroidism. Cattell and Perkin (3) have recently called attention to the use of the pre-operative blood iodine level as a means of determining the cases that may recur. In a study of a group of 256 patients with exophthalmic goiter they found that all of the recurrent cases occurred in those patients having a pre-operative normal or low blood iodine. In the group of patients observed, approximately one-fourth had a normal or low blood iodine, yet all cases had an elevated basal metabolic rate. Furthermore, Perkin and Lahey (15) showed that this occurred most frequently in patients who had had the disease for over 1 year. Cattell and Perkin (3) concluded that a more radical subtotal thyroidectomy should be done in a patient having a normal or low pre-operative blood iodine level. This has been the only means so far presented that may aid in the prediction of cases that may have a recurrence of symptoms. In our experience, recurrence of symptoms rarely follows subtotal thyroidectomy for nodular goiter with hyperthyroidism (adenomatous goiter with secondary hyperthyroidism). Patients with a discrete adenoma with associated hyperthyroidism may be relieved by removal of the adenoma unless the remainder of the gland is hyperplastic. We (4) have previously recommended that all of these patients be submitted to subtotal thyroidectomy in order to avoid recurrence since it is not always possible at the time of operation to determine whether hyperplasia is present in the remainder of the gland.

INCIDENCE OF RECURRENCE OR PERSISTENCE

During the 10 year period, 1928 to 1937 inclusive, 4,956 patients with hyperthyroid-

ism were operated upon at the Lahey Clinic. During this time, 306 patients were operated upon for recurrence or persistence of hyperthyroidism (Table I). It is difficult to determine a true incidence of recurrence or persistence unless all cases are carefully followed for a number of years after operation by clinical observation and by basal metabolism determinations. In a group of 190 cases reported by Thompson, Morris and Thompson from the Massachusetts General Hospital, 19.5 per cent had recurrence of symptoms. Jackson, in presenting 22 cases of persistent and 36 cases of recurrent hyperthyroidism, did not state the recurrence rate. Joyce found a recurrence rate of 5.7 per cent in his cases with hyperplastic goiter. Coller and Potter

TABLE I.—INCIDENCE OF PERSISTENT AND RECURRENT HYPERTHYROIDISM IN 4,956* CASES OF EXOPHTHALMIC GOITER FROM 1928 TO 1937

	No.	Per cent
Persistent hyperthyroidism	119	2.4
Recurrent hyperthyroidism	187	3.7
Total	306	

*165 patients had been operated upon previously at the Lahey Clinic.

reported 267 cases of exophthalmic goiter with a recurrence rate of 4.8 per cent. In our group of 306 patients, 187 were operated upon for recurrent hyperthyroidism and 119 for persistent hyperthyroidism. Of this number, 165 or 53 per cent, had their initial operation at this clinic. Of the total number of cases in which the original operation was done at the clinic, 1.76 per cent of patients showed further symptoms and were operated upon for this condition during the same 10 year period, yet this does not represent the true incidence of the condition. Perkin (16) studied 750 consecutive cases of exophthalmic goiter at the Lahey Clinic, followed for 2 years after operation, and demonstrated a recurrence rate of 5.2 per cent. The average duration of time between the initial and second operation for our cases of recurrent hyperthyroidism was 7 years and 11 months, while in the group of persistent hyperthyroidism, operation was delayed for 2 years and 4 months. Since it has been demonstrated that recurrence of symptoms may occur at any time after operation up to 10 years or more, all figures for recurrence are probably inaccurate.

There were 265 females in our series, or 86 per cent, and 41 males or 14 per cent, giving a ratio of approximately 6 to 1. The average age for both sexes was 39.5 years. In our experience, recurrent hyperthyroidism is rare in children.

TREATMENT

Three methods of treatment are available for patients with recurrent hyperthyroidism: radiation, medical, and surgical. Many of the patients with the mild recurrence of symptoms can be satisfactorily controlled with Lugol's solution. They should be carefully followed to make certain that their weight is maintained and that they are able to carry on a reasonable activity. Either medical or roentgen therapy can be used in the mild cases when the thyroid remnants are small. Operation is advised for all patients with persistent hyperthyroidism who are not relieved by medical measures. It has been our policy to do a subtotal excision of thyroid remnants in all cases in which the remnants are demonstrated to be enlarged, when weight is not maintained, when the basal metabolic rate is elevated, and when incapacity is present. The pre-operative preparation is the same as for other patients with hyperthyroidism.

It must be admitted that the secondary operations on the thyroid gland are frequently difficult and unless unusual care is exercised, postoperative complications may occur (Table II). A wide and adequate exposure of the entire gland is even more necessary than in a primary operation if injury is to be avoided to the internal jugular vein, parathyroid glands, and recurrent nerve. The prethyroid muscles should be divided, although it may be impossible to remove the sternothyroid muscle from the gland remnant. The internal jugular vein is then identified, dissected free, and retracted in order to obtain a wide lateral exposure. It is our practice routinely to expose and identify the recurrent nerve and make a careful search for the inferior parathyroid gland. The pyramidal lobe is removed if

present, as well as all thyroid tissue over the trachea. Small portions of thyroid tissue are left along each side of the trachea, preserving as much of the thyroid capsule as possible. In this way the parathyroids will be preserved even though they cannot be identified. A more radical removal of thyroid tissue is carried out in all recurrent cases, as compared to the removal in primary operations.

POSTOPERATIVE COMPLICATIONS

The operative mortality in the 306 patients operated upon for recurrent and persistent hyperthyroidism was 1.9 per cent (Table II). This should be compared with our total mortality in all patients operated upon for exophthalmic goiter of 0.67 per cent. Postoperative parathyroid tetany occurred in 2.9 per cent of the series, as compared with 0.2 per cent in patients not having previous thyroid operation. This high incidence of parathyroid tetany is due to the difficulty of identification of the parathyroid glands during the secondary operation. As stated earlier in this paper, we estimate the incidence of recurrent hyperthyroidism in our cases to be 3.3 per cent. After subtotal excision of thyroid remnants, 9.2 per cent of our patients still presented symptoms of hyperthyroidism. This strongly suggests some extrathyroid phase of the disease. The most common postoperative complication was recurrent laryngeal nerve injury. Either temporary or permanent injury to one nerve was noted in 14.7 per cent. This high incidence of recurrent nerve injury has been one of the factors responsible for Dr. Lahey's (12) recommendation that the recurrent nerve be visualized routinely in thyroid operations. If this be done, we know that this figure will be greatly lowered. Six and two-tenths per cent of our patients showed postoperative hypothyroidism. This figure is not greatly in excess of the 4 per cent incidence in primary cases. Postoperative hemorrhage and wound infection occurred in a somewhat higher proportion than in primary operations. We wish to emphasize particularly the high occurrence of postoperative complications following subtotal excision of the thyroid remnants, for it further emphasizes the seriousness of recurrent hyperthyroidism.

TABLE II.—INCIDENCE OF POSTOPERATIVE COMPLICATIONS FOLLOWING SUBTOTAL THYROIDECTOMY

	Primary operation (4956 cases) per cent	Second operation (306 cases) per cent
Recurrence	3.3	9.2
Hypothyroidism	4.0	6.2
Parathyroid tetany	0.19	2.9
Recurrent laryngeal nerve injury	2.0	14.7
Wound hemorrhage	0.5	2.6
Tracheotomy	0.1	2.6
Wound infections	1.0	1.6
Operative mortality	0.67	1.9

SUMMARY AND CONCLUSIONS

Persistent hyperthyroidism follows inadequate subtotal thyroidectomy and should be treated by subtotal excision of thyroid remnants.

A series of 306 patients operated upon for persistent or recurrent hyperthyroidism during a 10 year period is presented.

Radical subtotal thyroidectomy is recommended for all patients having a pre-operative normal or low blood iodine.

Subtotal excision of thyroid remnants is a difficult operation and may be followed by a high incidence of postoperative complications. Means of reducing complications are discussed.

Patients having recurrent hyperthyroidism resulting in inability to maintain weight, with an increased metabolic rate, and inability to work, should be treated surgically.

BIBLIOGRAPHY

1. Brenizer, A. G. Amount of gland to be left at thyroidectomy. Ann. Surg., 1933, 97: 831–843.
2. Cattell, R. B. The iodine treatment of exophthalmic goiter. Tr. Second Internat. Goiter Confer., Berne, Switzerland, 1933.
3. Cattell, R. B., and Perkin, H. J. Recurrent hyperthyroidism. Blood iodine values in determining recurrence. Surg., Gynec. & Obst. In press.
4. Cattell, R. B., and Eckerson, E. B. Single discrete adenoma of the thyroid with associated secondary hyperthyroidism. Surg. Clin. N. America, 1936, 16: 1631–1637.
5. Coller, F. A., and Potter, E. B. The end-results of thyroidectomy. Ann. Surg., 1931, 94: 568–581.
6. Crile, G. W. Recurrent hyperthyroidism; neurocirculatory asthenia and peptic ulcer; treatment by operations on suprarenal sympathetic system. J. Am. M. Ass., 1931, 97: 1616–1618.

7. ELSE, J. E. Prevention of recurrent goiter. Surg. Clin. N. America, 1928, 8: 1375–1394.
8. GILLETTE, N. W. Recurrent hyperthyroidism. West. J. Surg., 1937, 45: 504–510.
9. JACKSON, A. S. The prevention of persistent and recurrent hyperthyroidism based on a study of 769 cases of exophthalmic goiter. Surg., Gynec. & Obst., 1934, 58: 590–594.
10. JOYCE, T. M. Thyroid surgery at the Portland Clinic. Tr. Am. Surg. Ass., 1931, 49: 149–153.
11. LAHEY, F. H., and CLUTE, H. M. Persistent and recurrent hyperthyroidism. Ann. Surg., 1926, 83: 199–205.
12. LAHEY, F. H. Routine dissection and demonstration of the recurrent laryngeal nerve in subtotal thyroidectomy. Surg., Gynec. & Obst., 1938, 66: 774–777.
13. Idem. How much thyroid tissue should be removed in toxic goiter? Ann. Surg., 1932, 95: 529–536.
14. PEMBERTON, J. DEJ. Recurring exophthalmic goiter: its relation to the amount of tissue preserved in operation on the thyroid gland. J. Am. M. Ass., 1930, 94: 1483–1489.
15. PERKIN, H. J., and LAHEY, F. H. Exophthalmic goiter; relation between blood iodine level and duration of symptoms in 305 cases. Arch. Int. Med., 1938, 61: 875–879.
16. PERKIN, H. J. Personal communication.
17. SCOTT, A. C., JR. Surgery of recurrent exophthalmic goiter. Texas State J. M., 1937, 32: 649–652.
18. THOMPSON, W. O., MORRIS, A. E., and THOMPSON, P. K. Thyrotoxicosis following subtotal thyroidectomy for exophthalmic goiter. Arch. Int. Med., 1930, 46: 946–978.

CONTRACTURES DUE TO BURNS

W. T. COUGHLIN, M.D., F.A.C.S., St. Louis, Missouri

A CONTRACTURE is an abnormal shortening of the soft tissues whereby skeletal structures, and often the adjacent soft parts as well, are drawn into and fixed in abnormal position, so that the form is disfigured and the function interfered with. It has long been known that scar tissue contracts as it gets older, and all have noticed that those wounds which healed the most rapidly left the least scar.

Burns take longer to heal than wounds due to mechanical trauma, and almost all those of the third degree suppurate. The pyogenic process is an additional source of irritation to the already injured tissues and a greater production of new connective tissue occurs. Also, these injured tissues require a longer time to heal because not only have surface cells been immediately destroyed, but those directly below have been so seriously injured that they soon die, while those remaining viable are injured in decreasing degree of severity from the surface to the depths where normal tissues remain. Such injured cells cannot respond to the injury until they recover their vitality.

But it is not alone the amount of connective tissue that is the cause of the contracture, for a part, if allowed to heal in the position of greatest ease, may be the site of a disabling contracture, even though scar tissue is present in a very small amount. Joints assume the position of greatest ease by reflex rather than by voluntary action. The underlying muscle contracts to relieve the tension on the burned surface area. If, while in this position, the muscle or the tendon becomes fixed in its sheath—and a very slight amount of exudate in either may be sufficient to cause it to do so—the contracture is continued by the connective tissue, though not primarily caused thereby.

The prevention of the contracture would be better than its cure, but prevention may not be possible. Theoretically, since the contractures follow burns chiefly on the flexor aspects of joints, all that is needed to prevent contracture is the continued immobilization of the part in hyperextension during healing, and in complete flexion for a burn on the extensor surface. In treating burns of adjacent sides of fingers or toes, the fingers would be held widely separated; and for the burn in the axilla it would only be necessary to hold the arm in complete elevation, or at least in complete abduction during healing.

No matter what the treatment may be in theory, in practice one is obliged to have regard for the comfort of the patient and the feelings of his friends. Even though one may begin the treatment of an extensive burn with a full understanding of the need for such safeguards and with a zeal for carrying them into execution, his best efforts are often the cause of increased discomfort and complaint; his ingenuity and his patience are taxed beyond capacity; and, finally, his convictions yielding to his compassion, the doctor takes the easiest way and the part heals in the position of greatest ease.

The immediate treatment of the burn will do a great deal toward shortening the time in the hospital, lessening the suffering, and diminishing the late contractures. Just as soon as shock is past the patient or the part should be anesthetized—and never with a drug which irritates the kidneys—and the burn should be cleaned and sterilized like any other wound, all dead tissue cut away, and the surface

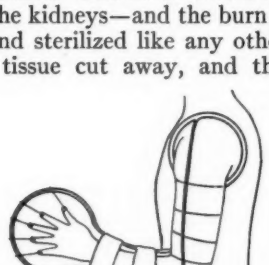


Fig. 1. A splint that keeps fingers apart.

From the Department of Surgery, St. Louis University School of Medicine.

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17-21, 1938.

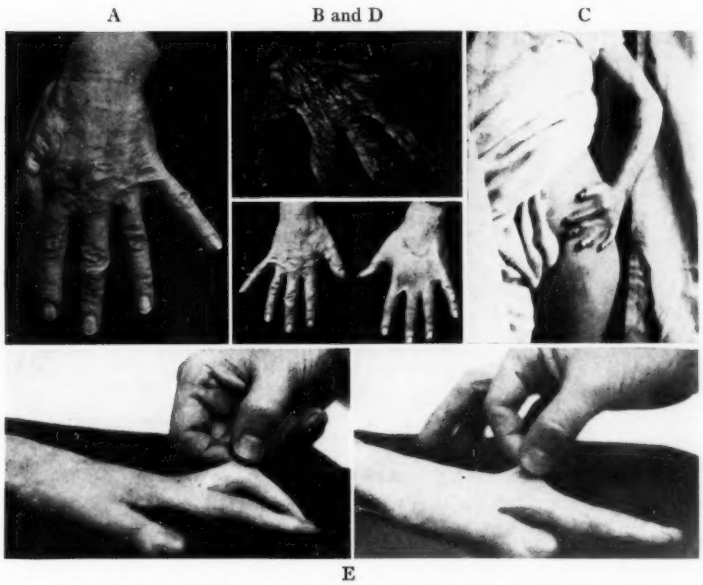


Fig. 2. A, The hand has been burned and is unsightly. The first 2 fingers and thumb are webbed. B, The amount of scar removed. C, The hand is in a pocket to cover part of the back of the hand, a separate compartment for each finger. D, Final result. E, The skin is freely movable and can be pinched up like normal skin.

sprayed with 5 per cent aqueous solution of tannic acid at least twice an hour until the crust (coagulum) forms. Thereafter the injured part or the patient is kept naked under the warm tent and made comfortable. After about 3 weeks, or whenever the crust is loosening at the edges, the crust is to be removed and warm hot boric packs applied for a few days when skin grafting should be begun.

Early skin grafting is conducive to a more rapid healing and anything which does this will lessen the contracture. Of all types, the simplest to do is the Reverdin procedure and it can be begun almost as soon as granulations are first seen. It possesses this great advantage that no regular operation is needed. A few grafts may be set at each dressing and by sticking the graft in an oblique slit in the raw surface (the method, I think, of John Staige Davis) one's efforts give excellent results. The Thiersch and the Wolf grafts never have much chance as long as there is pus present, and they require an operation but serve well on sterile wounds.

About the best apparatus for the burned hand is some form of the banjo splint. I do not remember who first devised it and the method of using the finger nails to aid in the holding of the fingers in an extended position, but certainly it is most satisfactory (Fig. 1).

When the wrist is burned all the way round, a similar device is used, but this is part of a wire frame splint which fits forearm and arm. Whatever apparatus is used it is much better if it does not touch the burned area and, of course, it must not press on any part of it. Any apparatus will somewhat interfere with the dressings, but one should manage to change the dressings without removing the apparatus. The changing of dressings now is never the ordeal it once was. The open treatment has almost entirely abolished them during the early period, and cellophane, rubber strips, and the olive and cod liver oils have robbed the terror from those dressings necessary later.

The contractures about the hand are like those elsewhere, either of flexor or extensor

A B

Fig. 3. For dorsum or palm, the double pedicled flap is safest. Its pedicle can not become twisted or kinked. A, Note how the flap has been cut a little at a time until it is ready to be entirely separated. B, The plaster-of-Paris does not give quite enough support. The flap should bear no weight.

A B

Fig. 4. A, The flap is long enough to cover both dorsal and palmar aspects. B, After it has adhered to the dorsum, it is cut free above and allowed to fall down, the flap being attached to the palmar aspect.

type and either may be quite disabling. When the hand is burned in infancy or early childhood and repair of the ensuing contracture neglected or deferred, it must not be forgotten that the involved bones and joints will never develop normally; and that no procedure undertaken after the child has grown up can ever yield such good results as can be obtained when reconstruction is begun as soon as possible. And it is not only the changes in development that occur. Even in adults the joint that has long occupied an abnormal position cannot be restored to its normal position by cutting away the scar. The ligaments on the flexor side become so shortened that they prevent complete restoration and certain intra-articular changes often occur which still further prevent a return to normal. Therefore, all contractures should be treated early.

The skin alone is hardly ever the only tissue involved in the scar. The fascia is, as a rule, the one which causes most trouble, although occasionally muscle shortening may call for a tenotomy, or articular ligaments may have to be cut. In those cases wherein joint changes have occurred, it is better to get good, loose, soft parts first to replace those that were shortened and then attack the joint. The reason is that in flap operations suppuration is not very uncommon, and when joints have been opened this will most likely lead to total ankylosis if suppuration should occur.

How to treat the particular case must always be the chief question. No set rule will do for all. For some of only slight magnitude a simple removal of the skin scar followed by simple, thick, Thiersch skin graft will do, or perhaps by a whole thickness skin graft. These methods of repairing surface defects have much to recommend them and will always, I think, have a large place in surgery. I feel, each time I use one, that I am performing a new experiment because it has happened repeatedly in my practice and in our surgical service that these grafts have often healed in perfectly and then some time after the eighth or tenth day have begun to die from the surface inward; sometimes the entire graft has been absorbed, and in others absorption ceased before the glandular epithelium has been entirely destroyed. In either case the result was far from good. Then, too, there is the ever present possibility of infection; so many actually take part in an operation besides the patient. And the Thiersch or Wolf skin graft to be successful must be sterile from first to last.

In most instances it is desirable to have fat between the skin and the underlying structures. That is one reason why almost everyone has fat so placed. After removal of the scar in those severe contractures about the hands, the feet and the neck, it is highly desirable to have the replaced skin in such condition that it is movable over the under-

Fig. 5.

Fig. 5. Flexion contracture of elbow can be benefited by the Z incision (Fig. 6 A, B, C), the division of the bicipital fascia and tendon lengthening (Fig. 6 D, E). A transverse uncovered area may remain just in front of the joint (Fig. 6 F). A flap from the side at the elbow level with its base forward suffices to fill this (Fig. 6G, H).

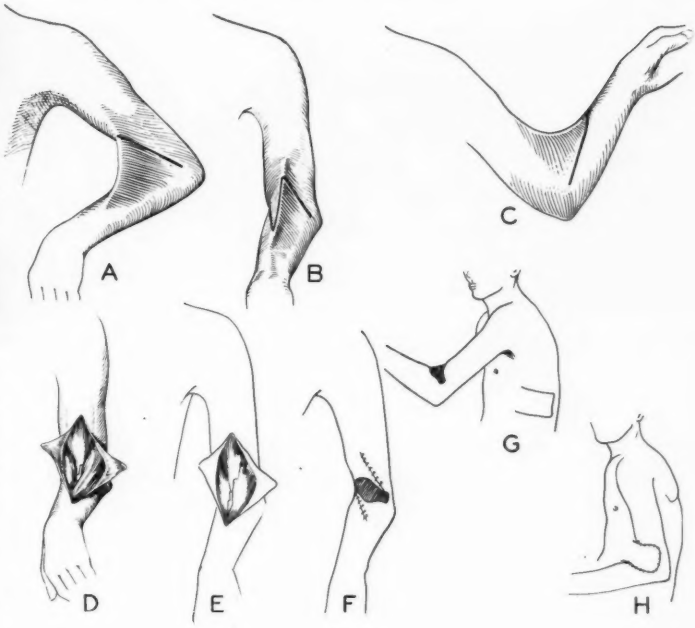


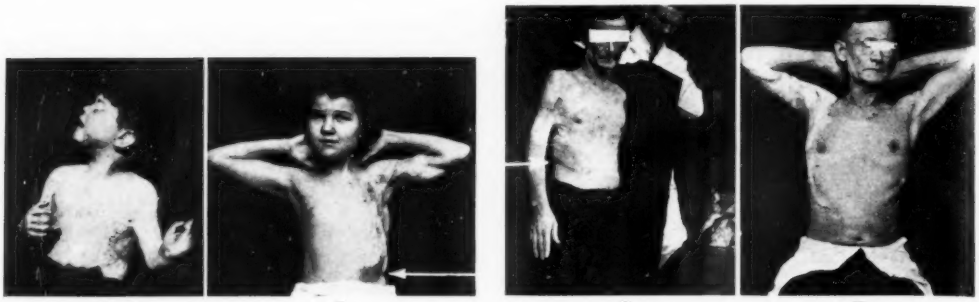
Fig. 6.

Fig. 6. A, B, and C illustrate the Z incision. D and E, The flaps have been turned back and a tendon-lengthening done. F, On straightening out the elbow, there is always a transverse area left uncovered after the flaps have been sewed into their new positions. G and H, Such a defect at the elbow is easily covered by a flap from the side, base forward.

lying parts and these are mobile under the skin. This is possible only if a layer of fat, or loose areolar tissue, lies under the skin. All the normal fat and areolar tissue have been destroyed and removed. The best method for such reconstruction is by some means of a flap.

When the scar is on the dorsum of the hand, fingers, or wrist, the new parts for repair of the lesion are got from the anterior part of the abdomen or thigh; for the repair of a palmar lesion of hand, fingers, or wrist, from the patient's back or buttock. When fingers are to be covered, separate compartments are made for each finger (Fig. 2 C). One should be sure the compartment is larger than the finger, otherwise death of the finger may follow. Or, if the tip of a finger is brought out through a slit in the skin, the slit must not be made so small that sloughing of the finger tip ensues. Again, the fingers are sometimes *sutured in*. This is dangerous as well as painful and hardly ever necessary. A bit of adhesive to the exposed tip will do. A suture has been tied around the finger and the finger has sloughed. Whole thickness grafts or Thiersch grafts, either thick or thin, do not give such good finger covering (in the author's practice) as those made by means of the flap. All excess fat can be removed easily when necessary and under local anesthesia. The result is a skin covering which is joined to the deeper parts, or separated from these by a layer of loose connective tissue and the skin moves freely on the deeper parts and is not so subject to trauma (Fig. 2 E).

When only dorsum or palm is to be cared for the double pedicled flap is safest and its pedicle cannot become twisted nor kinked as can that of the single pedicled one (Fig. 3). The beginner usually makes it too thin or fastens it to the hand too tightly and sloughing occurs across the middle with total loss. This is a great calamity. It can be avoided by having it wide enough and long enough so



A B C D

Fig. 7. For those which involve the upper third of the arm or more, a flap of skin and fat gives the best result. B and C, Notice the distance that the tip of the flap has had to travel.

that the hand can easily be passed under it and then slid up and down for an inch either way. It need not make an exact fit but ought to be wider than the area to be covered. If it is tight at the end of the operation, it will be better to loosen it at that time than later. It is important to have fat enough attached to the flap, and less than half an inch of fat is bad for a beginner. If there is too much fat it can always be removed later; but if too little is left attached to the flap, this will probably die. Another thing the beginner forgets is that such flap-sling or pocket must never bear or carry the weight of the hand as a sling does if the patient sits up or goes about. There should be no pressure or tension on a flap (Fig. 3 B).

Sometimes there is scar both on palmar and dorsal aspect of hand or wrist. In these, much time and suffering can be saved by making the same flap do for both surfaces (Fig. 4 A, B). After it has healed on 1 surface the lower end of the pedicle is cut free and the hand rotated 45 degrees, pronated or supinated as the need may be. The scar on the border of the hand is removed and the flap is lengthened and fastened down to this. After another week or 10 days the flap is cut entirely free and long enough to cover the surface remaining to be denuded.

The flexure contracture at the elbow (Fig. 5) can be much benefited by the Z incision, the removal of underlying scar (Fig. 6 A, B, C), the probable division of the bicipital fascia, or even more of the deep fascia, and a lengthening of biceps tendon (Fig. 6 D, E). I think a transverse uncovered area just in front of the joint will almost always remain

A B C D

Fig. 8. A, Something must be done at once in order to allow the face and jaws to develop. B, A flap is brought from under the chin, and the lip and upper part of cheek are unrepaired. C, Massive flap brought from patient's back. Note zigzag line of scar from lip down to chin. A straight-line scar will shorten and pull the lip down later. D, This is how she has grown up.

C E F G H

A B D

Fig. 9. A, Six months after accident. B, Flaps have been wheeled upward and inward after excising the scar below the jaw. C, The head is dressed well back. D, A flap from the arm (Tagliacozzi) is used to make the lower lip. E, But lower lip and chin are still attached to neck. A tubed flap (Gillies) is in the making. F, The tubed flap has been swung up and is going to replace all of the scar reaching from chin to chest. G, The flap has been used twice (note above and below) and is now being used the third time. Note lateral view of neck and chin. H, This shows what the years have done for him, age 23. Could be much improved by retouching but he "hasn't time."

(Fig. 6 F). A flap from the side at the elbow level with its base forward suffices to fill this (Fig. 6 G, and H). Such a flap should be at least 2 full inches across at its tip and not less than 3 inches wide at its base. If one has not had experience with this flap he had better begin the making of it before touching the arm. By fastening a piece of cloth to the patient's side and laying it across the arm in front of the elbow on the wound side, he can get some idea from where the flap should be lifted, where the base should remain attached, and where the apex should be. Its outline can then be scratched on the skin and, beginning at the tip, 2 inches of it can be lifted the first day, and replaced and lifted another inch or so in 3 or 4 days. This is repeated until the whole length has been lifted up. It will now be surely viable when transferred to the arm. Closing defects left on the wall of chest or abdomen is usually a very easy matter if one undercuts the superficial fascia and uses strong relaxation sutures.

Cutting a flap free may sometimes be followed by loss of the flap, the part transplanted not having sufficiently healed on. This does not happen if clean healing has occurred and if the pedicle has not been cut before 15 days. Trying to hasten the procedure is not always the best way to secure success, and if there is suppuration one had better make sure by waiting at least 3 weeks. By constricting the pedicle with the fingers and watching for color change in the flap, one can tell when the flap becomes viable, for then constriction of its pedicle causes no change of color. When there is any doubt as to the viability of the flap the pedicle or pedicles should be severed slowly. By cutting a little every day or two, Nature seems to make the blood supply answer the demand (Fig. 3 A).

A very disabling contracture is that which holds the arm to the chest wall after a burn involving the axilla. The two shown (Fig. 7 A, and C) are quite extensive. For those of only slight extent the zigzag incision as in Figure 6 A, B, and C will do. Even a skin graft through a perforation in the middle of the base of the web will suffice. A perforation without a graft allowed to epitheliate through

Fig. 10. A and B, Condition after treatment with whole thickness graft 3 years previously. C, The flap has been raised from the back to conceal the scar. The scar, unsightly at first, can be narrowed a little at a time by the method of Neu, if this seems desirable. D, E and F illustrate the condition of the patient 3 months later when she returned to the hospital to have a small portion of the flap removed.

along a seton, as the *pierced* ear does, and then cutting through from this opening to the surface will do well enough when the web is thin and small, as in the case of web fingers. For those which involve the upper third of the arm or more, however, I think a flap of skin and fat gives the best result. It may be that the flap must come from some distance as in Figure 7 B and C. If so, it may be better to raise it in several steps. At times, indeed, so much is burned nearby that nothing short of a tube-pedicled flap (Gillies) will do.

A B C

Fig. 11. A, Patient burned 9 years previously and operated upon elsewhere. B, A flap from the back, after being cut free at its lower end, is drawn up many times daily toward the position it is going to occupy, until it can retain its color. It is then ready to apply. C, All of the scar tissue between the surface and the hyoid bone is cut through and the flap is sutured into the raw area. Retouching later can make it look much better.

I have used this latter kind of flap a good deal for contractures of the lower jaw and I like it better the more I use it. Many of these contractures follow burns in childhood (Fig. 8, 9) and something should be done at once, for as the child grows, skeletal deformities will occur involving the lower jaw, upper jaw and spine and these cannot be corrected afterward.

Here again the treatment must vary with the extent of the burn. The zigzag incision (Fig. 6 A, B, and C), the thick Thiersch graft

A B C D

Fig. 12. A, A whole thickness graft at the end of 5 days. It is changing from blue to pink. B, the same, 5 days later. No infection. C, The same. Healing has occurred but scar is still present. D illustrates a lateral view of the same patient. This has never occurred with any of our pedicle grafts.

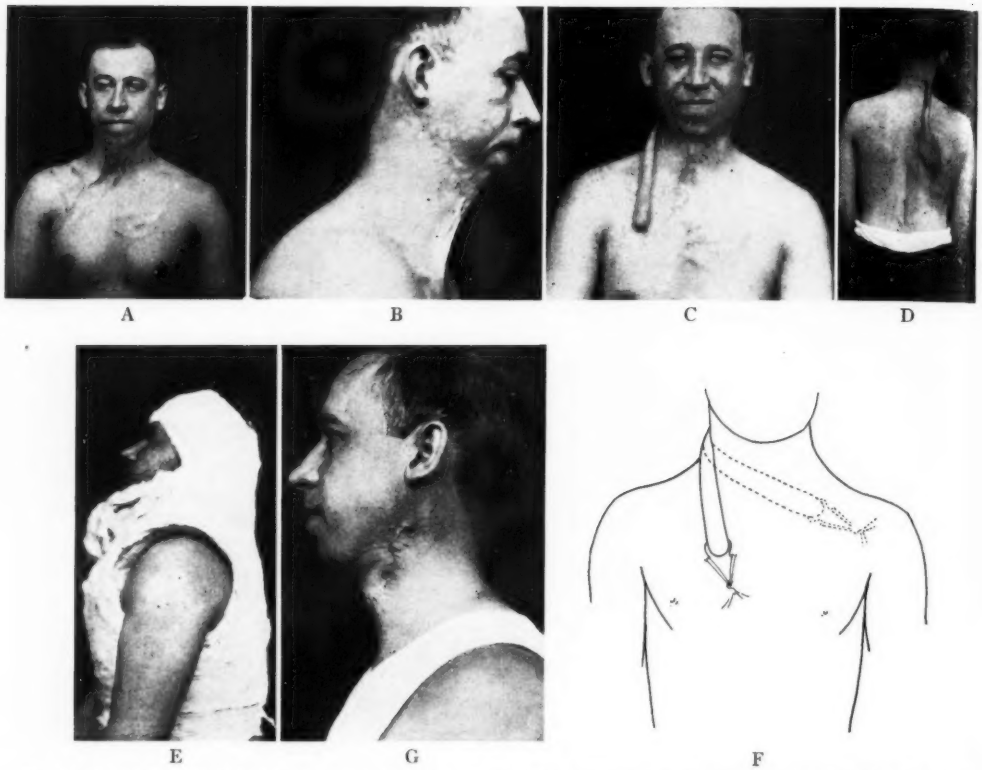


Fig. 13. A and B, Patient had been operated upon elsewhere. Burned at 5 years of age. C and D, The flap is being lengthened. It was finally long enough to enable us to use it twice. E, A plaster-of-Paris cast is applied to prevent another catastrophe, turning of the head or kinking of the pedicle. F, To illustrate the manner of stretching the flap and the manner of gradually bringing it to its new bed. G, As he left us.

Fig. 14. A and B, Front view and profile to show extent of scar. C, The flap is being got from nearby. It has been lifted to one side in order to show the bed. The lower part of the bed has already been skin-grafted. D and E show the scarring and the appearance some time afterward. This was one of the quickest repairs, 23 days.

or the whole-thickness graft may do for the small shallow burns, but they are a waste of time with the more severe cases (Figs. 10, 11, and 12). For boys and men sometimes it is very convenient to throw in a flap from good skin near by, in them a scar more or less is of no moment; but for the girl one ought to consider the scar left after raising a flap and if possible keep it out of sight.

The tube-pedicled flap from the back is very satisfactory. It may be that it isn't wide enough to cover the whole area when it is unfolded. This must be foreseen and it can be made long enough so that it may be used again and again, as many as 3 times if necessary (Fig. 9 F, and G). Not only this, but it can actually be stretched and made long enough to make up for a certain deficit (Fig. 13 C, and F). In this case (Fig. 13 D) we lost the open part of the flap because of kinking of the tail on the second night. The patient turned while asleep. What remained was too short to reach and too narrow to cover the defect. Extension was at once applied and the patient was shown how to increase or decrease the pull and the direction. In about 6 months it reached almost to the other ear and we used it twice (Fig. 13 C). In some others we have lengthened the pedicle by hanging a weight on it by day and using the elastics at night. The patients learn to apply these themselves and may telephone and return when ready. One objection is the added time, but this doesn't outweigh the many advantages.

One can get a flap from a closer area and without tubing the pedicle as shown in Figure 14. In this case time was of prime consideration. A large flap was lifted half way up the denuded area, Thiersch grafted, and the flap replaced. In 4 days the remainder was raised and grafts placed under it. At the end of 8 days from the beginning the flap was swung into place and healed *per primam*. It was necessary for the patient to stay in the hospital only 23 days.

THE EVOLUTION OF FRACTURE TREATMENT

ISIDORE COHN, B.S., M.D., F.A.C.S., New Orleans, Louisiana

THE evolution of fracture treatment has necessarily been a slow process. The story of fractures through the ages is a definite challenge to the industry and enthusiasm of the present and future generations. As we read yesterday's record preserved by faithful historians, we cannot help but marvel at the powers of observation which enabled the master surgeons of the past to diagnose and treat fractures without the aid of modern scientific adjuncts. One wonders at the temerity of surgeons prior to the introduction of anesthesia. How they were able to reduce deformity caused by fractures without the benefit of anesthesia, will always remain a tribute to the heroism of patients. How simple, in a way, this particular great gift has made the management of these cases is not appreciated by our generation.

From Hippocrates through Galen, de Chauliac, even down to the latter part of the nineteenth century, there were lengthy discussions about matters which today even a first year medical student would consider primary information. This information was not available to the greatest surgeons of the past; they had to depend on their knowledge of anatomy and of logic, and based on these alone we find great treatises written on the subject as to whether one position or another was better, or whether one splint or another was preferable. To the credit of the ancients we should say without hesitation, that many of the things which are being rediscovered today were utilized by our forefathers, if not entirely, certainly in principle, and in many instances they all but stumbled on the things which seem so important today.

"Hundreds of the profession have derived their celebrity from our general ignorance of the learning and attainments of Galen, by stripping the laurels from his honored brow, from which they unduly weaved a wreath to place around their own, altogether undeserving of it."[1]

Each generation looking back at the history of the past speaks of itself as modern and the older generation as ancient. It is probable that the next generation will think in terms of ours with the same attitude as we look on those of the past. We trust that they will show as much respect for us as we must show to those who preceded us.

Our respect is due to Galen, de Chauliac, Paré, and a host of others who accomplished so much with the only means available, their powers of observation and anatomical knowledge. Their example should stimulate us to emulate them.

It becomes our duty to insist on a greater amount of practical application of the anatomical information which is available.

Our own generation should avoid making use of short cut methods and special gadgets.[2]

"The very facilities we possess are among the chief causes of our imperfection. Like the hero in the fable, we lie down in repose in full persuasion that the hours of indolence may be easily regained."[2]

It is our duty to teach fundamental principles, as principles alone should guide us in the management of fractures. We will discuss evolution in terms of principle and not in terms of particular apparatus or particular fractures. If we were to attempt to discuss evolution of the treatment of any one fracture, it would carry us too far afield. This discussion will be limited to principles which have to do with the diagnosis and treatment of fractures, bacteriological principles, x-ray, and industrial developments, which have done so much toward making our present methods possible.

Let us not think in terms of what a man calls himself, whether he calls himself a gen-

From the Surgical Department, Touro Infirmary and Charity Hospital.

Fracture oration before the Clinical Congress of the American College of Surgeons, New York .October 17–21. 1938.

[1] The writings of Hippocrates and Galen. Epitomized from the Latin and translated by John Redmond Coxe. Published in Philadelphia, 1846.

[2] Magnuson, Paul. Fundamentals versus gadgets in the treatment of fractures. Fracture Oration. Delivered before the Clinical Congress of the American College of Surgeons, 1935.

eral surgeon, fracture surgeon, bone and joint surgeon, orthopedist, or what not. It is fundamentally important that the surgeon, who is best prepared to treat fractures, should treat the injuries of our race. They are those who have given of themselves and who are willing to continue to give service and time in order to study and prepare themselves to bring back the disabled individual to his normal capacity as quickly as possible. Names should be disregarded; a common cause—the individual who has been injured—is to be considered primarily. "Disown not your own offspring, yet be not disavowed by your progeny." This may well be the attitude of surgeons toward those of special groups who attempt to cast out the parent body. They have forgotten or do not know to whom they are indebted for the present high position of the surgeon in relation to fractures. If we were to think in terms of one of Shakespeare's great plays, the surgeon might be compared to King Lear, who provided for the offspring and then was cast aside as unfit. This seems to be the attitude of some branches of surgery today toward the general surgeon.

FRACTURE SURGERY

Let us consider surgery as the application of one's knowledge of anatomy for the relief or cure of a pathological condition. Let us remember, too, that today's axioms were mysteries beyond the horizon of yesterday. The horizon had enshrouded the x-ray, bacteriology, and anesthesia. Therefore, surgery could not progress. The evolution of knowledge had not reached out into the field so clearly defined for us today. Surgery of fractures had to stagnate.

With all of our good fortune have we attained the heights which we should have, or have we followed too closely the dictates of the past? Having defined surgery as the application of one's knowledge of anatomy for the relief or cure of a pathological state, we cannot help but think of surgery as manual in its conception. Fracture surgery is not different from other surgery. It is distinctly, not merely, the treatment of broken bones.

The treatment of fractures implies the utilization of the best knowledge of the surgeon, as well as the application of the minute knowledge of our forefathers of surgery. They passed from the degraded position of "barber surgeon," through the stage of consort to "sack-em-up men," until today they are the high priests of the suffering, the sculptors repairing the finest work of the Great Architect.

Who were the ancestors of the fracture surgeons of today? In this survey of the evolution of fracture treatment we have elected to begin with the writings of Guy de Chauliac. No matter where one attempts to make his initial investigation he will find literature of value antedating the entrance of his earliest hero on the scene. If we were to accept Hippocratic writings as a starting point, we would become disillusioned immediately. In an epitomy of Hippocrates and Galen, published in 1846, by Coxe, we find:

"We cannot in full force of the term admit, that the title of Father of Medicine is justly his due without encroaching on the rights of others; especially since it is incontestably proved by many that these treatises, we admire as his, have really emanated from other sources."

Hippocrates would not have claimed originality for himself:

"People rather admire what is new, and what is strange they prefer to what is obvious." (Hippocrates.)

As a warrant for electing to begin with de Chauliac, I quote from Desault:

"Celsus only copied Hippocrates, adding nothing to his mode of practice. No new method distinguished the surgery of the Arabians. It is necessary to come down to the time of de Chauliac before we meet with the method which is almost universally adopted at present."

What were the diagnostic signs by which the fathers of surgery recognized fractures, and what were the principles of treatment? de Chauliac taught:

"The signs of fracture are manifest to the senses. If the hand is placed on the region and touches the limb, it finds the part of the bone separated one from the other, and variable, and the figure of the limb abnormal. In palpating with the hand a crackling is heard in the bone, and pain when the spot is touched, and lack of power to sustain it in place."

Already the pioneer was teaching the value of inspection, palpation, manipulation, and

mensuration, the importance of pain, change in the axis of the limb, loss of function, abnormal mobility, and crepitus.

As one further reviews the literature he finds that he has to go down the ages to 1758, to the epoch-making work of Heister:

"It is no difficult matter to examine fractures of the bone:

"1. By the eye, when the injured part is apparently shorter than the sound, or when you see that the patient cannot make use of it.

"2. By the touch, when you perceive a preternatural inequality of the bone, or that it bends in a part where nature never intended it should; and here by the way, we must recommend it to surgeons, if it be possible to fix the patient immediately at the first searching of the fracture, where he is to lie during the course of the cure.

"3. By the ear, when we hear the ends of the broken bones crush against each other upon moving the limb."

In 1832, Sir Astley Cooper stated:

"Some of the symptoms of fractures are nearly conclusive. The crepitus, the change in the form of the limb, and the shortening of it, are circumstances communicating the most certain information."

America's own William Gibson, in 1832 believed:

"In general crepitation is more to be relied on than any other sign, and is an almost certain indication of fracture. Added to this there is usually more or less deformity, pain, swelling, inability to use or move the limbs."

Malgaigne, speaking for French surgeons in 1859, stated:

"The phenomena to which fractures give rise are crackling, heard by the patient at the time of the accident, pain, loss of power in the limb, contusion of the skin, swelling, or subsequent preternatural mobility at the seat of the injury, deformity from displacement of the fragments, and crepitation. If the finger be passed slowly and carefully over the whole length of the suspected bone, unless it has been subjected directly to external violence, the absence of all pain and pressure will prove its integrity; on the contrary, the existence of pain more or less severe at a circumscribed spot would afford strong presumption of a fracture. More than once from this sign alone, I have ventured to diagnose 'fracture.'"

This attitude on Malgaigne's part of recognizing the importance of localized pain is probably one of his greatest contributions. If that particular teaching were more generally followed, there would be fewer patients treated today for so called sprains.

In 1866, Hastings Hamilton published his remarkable work, the first of its kind in the United States. From this the following is quoted:

"In proceeding to establish a diagnosis in any case, the surgeon should sit down quietly and patiently with the sufferer, so as to inspire in him from the first, the confidence that he is not to be hurt or at least not unnecessarily.

"He ought then to inquire of him minutely as to all the circumstances immediately relating to the accident, in order that he may determine as nearly as possible its cause, which alone to the experienced surgeon, often affords presumptive if not conclusive evidence as to the nature and precise point of the injury.

"From this, he should proceed to examine the disabled limb; removing the clothes with the utmost care, by cutting them away rather than by pulling, and when completely exposed, should notice with his eye, its position, its contour, the points of abrasion, discoloration, or of swelling, and not until he has exhausted all of these sources of information ought the surgeon resort to the harsher means of touch and manipulation.

"Nor will his sensations guide him to the point of fracture by any other methods so accurate as when, the patient being composed and his muscles at rest, he moves the fingers lightly along the surface of the limb, pressing here and there a little more firmly according as a trifling indentation or elevation may lead him to suspect this or that to be the point of fracture.

"The limb may now be measured with a tape line and compared with the opposite limb, having first marked with a soft pencil or with ink, the several points from which the measurements are to be made.

"Finally, if any doubt remains the limb must be firmly but steadily held while the necessary manipulations are performed for the purpose of ascertaining the existence of mobility and of crepitus."

Samuel D. Gross, or the elder, in 1882 stated:

"There are only 3 symptoms which are at all reliable evidence of existence of fractures, namely, crepitation, deformity, and preternatural mobility. The co-existence of these symptoms is unmistakably denotive of the nature of the accident. Too much stress cannot be placed upon preternatural mobility as a sign of fracture. Next to crepitation it is unquestionably the most important diagnostic symptom.

"The physiognomy, or general expression of the affected part, often affords valuable diagnostic aid. The deformity for example of the hand and wrist in fractures of the lower extremity of the radius, the eversion of the toes in intercapsular fractures of the

femur, and the shortened and retracted appearance of the arm in fractures of the humerus are generally unmistakable evidence of the nature of the accident. The manner in which the patient inclines his head and supports the elbow and forearm in fractures of the clavicle, is too significant to be overlooked by anyone who has ever witnessed it. The peculiar aspect and the attitude of the broken thigh, conjoined with the utter helplessness of the muscles, or the absence of voluntary power are signs which seldom admit of misinterpretation."

It is interesting to compare the careful inspection, palpation, mensuration, advocated by Heister, Cooper, Malgaigne, Desault, Hamilton in 1866, and Gross in 1882, with the hurried advice, "have an x-ray picture taken," so often heard today. These instructions might well serve as a summary of all that was known up to 1895. To our diagnostic armamentarium was added the x-ray in 1895 by William Roentgen.

A review of the literature from de Chauliac to the latter part of the nineteenth century, reveals several salient facts: (1) Diagnosis was based on clinical signs and symptoms, pain, loss of function, crepitus, abnormal mobility, and physiognomy of the part; (2) a knowledge of anatomy was depended upon; and (3) painstaking observations were made. At this point they were forced to stagnate. For nearly 600 years no progress could be made.

Like a beacon across a storm-tossed sea, the light of opportunity burst upon us with the advent of the x-ray. What were some of the results of the introduction of the x-ray? It no longer was necessary to resort to manipulation, for the purpose of eliciting abnormal mobility and crepitus to satisfy one's self that the injured individual had a fracture. In fact, it then became the duty of the teacher, to insist that the traditional crepitus and preternatural mobility should not be sought. Unfortunately, diagnostic acumen seems to have fallen to a low ebb. The surgeons trained before the advent of the x-ray merely used the x-ray as an adjunct and as an essential, added factor, and they trained their students to do likewise.

The powers of observation from which one could note the loss of active motion, the change in the attitude of the limb, plus localized pain, obtained by light palpation, enabled the clinician to indicate nearly accurately where the fracture was and the x-ray was and is used by this group to confirm the diagnosis. For another group, who would take the "royal road," an x-ray is ordered immediately, and action taken on the result reported by the radiologist.

This innovation laid upon us certain obligations, obligations which I fear we have not altogether accepted. The x-ray provided us with a rapid means of diagnosis, but it also directed that we evaluate data not heretofore available; and it clearly indicated that all stored up knowledge gained by experience should not be cast aside. The new data consisted primarily of the visual image. It soon became evident that the visual image of bones varies with age. It became apparent at once to Poland, that a correct interpretation was needed of the appearance of epiphyses at all ages up to adult life so that the normal would not be mistaken for the abnormal. We soon learned that fractures through the epiphyseal lines could not be diagnosed by the x-ray in young children.

In the early part of the paper a statement was made that the ancients all but stumbled on some of the things which seem so important today. One of these has to do with the so called epiphyseal separations. In 1859 Malgaigne stated:

"I rank among fractures these lesions (epiphyseal separations), which some modern authors would consider as distinct from them."

According to Malgaigne, Bertrandi established by dissection the existence of so called separations of the epiphyses. Of course, he had no x-ray, therefore could only philosophize about the nature of the lesion, but he did say:

"When the solution of continuity is on a level and in the same direction with the epiphyseal cartilage the presumption is in favor of the decollation, but certainly can only be arrived at by an autopsy. Consequently aside from the complications the prognosis is the same as for the ordinary fracture near joints."

In 1866 Hastings Hamilton stated:

"Epiphyseal separations we shall not hesitate to class with fractures, and to submit them to the same rules of nomenclature."

The discussion still goes on. It is certainly to be hoped that in the near future we will recognize that all epiphyseal separations are in reality fractures. I believe we cannot escape this solution to the problem. We believe that the prophetic statement of the older surgeons on this point might well be adopted and that the term, "epiphyseal separation," be deleted from our surgical nomenclature.

It also became apparent that the hypothetical conditions, reverently spoken of as "sprains," were in most instances fractures. It is devoutly to be hoped that this antiquated term will soon cease to occupy the position of prominence which it does at present.

TREATMENT OF FRACTURES

When considering the principles involved in the treatment of fractures, one is confronted by a situation which is well summed up in the writings of John Bell, 1826:

"Ask a young man who has studied his profession faithfully what he would do with a fractured limb? He cannot tell. Ask the same question of one who has practised it well and sensibly. He cannot tell how he himself is accustomed to manage a fractured limb. He has no rule or settled methods. Ask the man of books and study what have been the doctrines of old, or what have been the actual improvements of the modern surgeon; he also is at a loss. Theories, bandages, machines, improvements, innumerable, he can well remember, but altogether with these recollections, this conviction always rests upon his mind, that the subject which he has long regarded as the most interesting is the only one which he has in vain endeavored to understand.

"There is no rule or principle yet established; this is almost the only department of practice which has been continually changing, without ever being improved."

In looking back over the literature we find much that we might quote from the masters of the past. Sound advice given by Hippocrates might well continue to be followed by those seeking to improve methods of treatment of fractures.

"Hippocrates tells us that medicine in all of its branches had been long established; that, they had found out the principle, and the route of discovery of many excellent things which would serve for the discovery of more, provided that those who undertook the task were fitted for it, and possessing a knowledge of what had already been done, would pursue a similar route."

de Chauliac taught the following:

"The general treatment of fractures follows the general intentions of wounds, and there are 4 principal intentions: The first is to equalize the bone; the second to preserve the equalized bone; the third to bind it with callus; the fourth to remedy complications. Before all things, one should prepare all that is necessary for the reduction. The necessary things are: Let one have a cradle or suspensory in which the limb will be firmly and evenly placed; a mattress bed on which the patient sleeps, and if it is necessary let it be perforated so that he may go to stool; a cord hanging over the bed or some other thing for him to catch and help himself when he wishes to go to stool or turn himself."

Here then are the fundamentals which were possible prior to anesthesia, asepsis, and the x-ray. When we would flatter ourselves about recent developments in the general management of fractures it should take no more than the above quoted statement of de Chauliac to humble us.

Sound advice, given by Heister in 1759 with reference to treatment of fractures, is the following:

"The surgeon's principal care in fractures is to unite the broken bones to which three things are necessary: (1) That the bone be restored to its natural situation; (2) that after the bone has recovered its natural situation, it may be kept there by giving it rest, and applying proper bandages; and (3) you are to use proper means to prevent or remedy the disorders that usually attend this accident. *The knowledge of anatomy is necessary to perform these intentions.*"

As early as 1805 Desault was pleading for the application of anatomical knowledge and physical principles in reduction of deformity and the maintenance of the reduction. He says:

"All kinds of apparatus for fractures being nothing but resistances opposed by art to the powers which produce displacement, it follows that they should all act in directions precisely opposed to the directions of these powers."

If more attention were paid at the present time to such fundamental anatomical and physical principles involved in this admonition, there would be less necessity for operative procedures in the treatment of fractures.

Sir Astley Cooper, speaking for the English professor in 1832, stated:

"The general treatment of fractures embraces three principal indications: The first is to reduce the pieces of bone into their natural situation. (Cooper favored immediate reduction.) The second is to secure and keep them in this state. And, the third is to prevent any unpleasant symptoms likely to arise and to relieve them when they have come on."

The interest and enthusiasm of the surgeons of that generation to obtain every available bit of information, so that they could improve themselves in the management of fractures, may be well appreciated by visiting the collections of specimens made by Cooper, Hunter, and others, to be found in the great museums of Great Britain.

Strange as it may seem, anatomical knowledge and surgical progress were inhibited by law. Stranger still is the fact that crime paved the way for the study of anatomy. Prior to the Warburton Act of 1832, which legalized the study of anatomy in England, the only subjects legally available for dissection were the bodies of criminals who were sentenced to be "dissected and anatomized." The teachers of anatomy at that time had to purchase bodies from "resurrectionists." These unscrupulous bands of grave snatchers carried their nefarious occupation farther and murder became an active business. One visiting Edinburgh today will see reminders of the activities of this band. The mort-safes in Gray Friars Cemetery bear mute testimony to the work of the "sack-em-up men." The life and usefulness of some of the great anatomists of that day were blasted by public indignation which was aroused by the proof of their association with the purveyors of human bodies. Nevertheless, the desire for knowledge and the hope of rendering service forced the courageous group of surgical anatomists to continue their relations, with resurrectionists.

"Sir Astley Cooper's usefulness to the world was based on his profound knowledge of anatomy, and this was gained by the careful dissection of bodies, which were supplied him by the resurrectionists. Thus did the end justify the means."[1]

The modern slogan, "Crime does not pay," was proved when Burke, Bishop, and Williams, were convicted and sentenced to death. Following their execution, public sentiment was sufficiently aroused to permit the passage of the act legalizing anatomical study. An act, which was thought then as now by some as a desecration, has proved to be a consecrating link of the past with the present and future welfare of the human family.

Knowledge of anatomy substitutes safety for boldness and daring. Cooper like many of his contemporaries realized difficulties incident to the management of certain fractures and the utter hopelessness of obtaining good results in certain fractures. This spurred him on in his desire to obtain specimens for study. From a report by Sir Astley Cooper, "On Fractures of the Neck of the Humerus," the following is quoted:

"Let the surgeon do what he will, the head of the humerus will probably remain in the axilla, and the upper motions of the arm will be in a considerable degree lost."

Astley Cooper proved himself more than an anatomist, more than an operator; he was a true surgical philosopher. The advice contained in the following admonition should be heeded by all who believe in the dictum that we should be generous to others and critical of ourselves, for therein lies the attitude which should characterize the unselfish seeker of knowledge:

"These cases should teach the members of our profession to be kind, generous, and liberal toward each other, and not to impute to ignorance or inattention that which is the result of a generally incurable accident. It too often happens that when every trial has been made to restore the parts and without success, the patient goes to some other surgeon to whom he shows his arm, and points out its uselessness and want of motion. A jealous and illiberal medical man might say, 'Yes, this is a dislocation which has not been reduced. I wish I had seen it at the first, but now it is too late for a successful attempt to replace it.' However, every intelligent well informed surgeon will now confess that no knowledge or exertion of skill could have prevented the deformity and loss of the natural motion which results from this formidable accident."

This eloquent plea is not only the philosophy of a generous man, but it is almost like a crying aloud in the wilderness for more help in the diagnosis of fractures. Such came with the advent of the x-ray.

[1]Ball, James Moore. Sack-Em-Up Men. Edinburgh: Oliver & Boyd, 1928.

We pass from England to France, from 1832 to 1859. In the preface to his treatise on fractures, Malgaigne indicates that his work is the first treatise in the French language limited to the subject of fractures. Malgaigne fulfilled his aim of, "Presenting a résumé of all the doctrines and ideas maintained from the earliest time to our own days, 1859." In vain one searches for a change of method or principle.

A brief résumé of Malgaigne's teachings follows:

"The treatment of fractures consists, generally speaking in the fulfillment of two principal indications: To reduce the broken ends and to keep them in place until consolidation is complete.

"The proper time for attempting reduction is a question that has presented itself ever since the earliest time, and has been variously solved by practitioners. According to Hippocrates, 'extension should be attempted on the first or second day.' Boyer and Larrey advocated in general immediate reduction and Velpeau also advocated immediate reduction."

Malgaigne concludes:

"It is indeed the first day that is generally the most favorable."

Anesthesia is not mentioned under the heading of treatment; and the old discussion of when to reduce was revived. On that point Malgaigne was as definite as surgeons of our own day. In Hamilton's epoch-making *Treatise on Fractures*, in 1866, the first treatise limited to the subject in America, we find several noteworthy contributions. It is the first treatise in which anesthesia is advocated for diagnostic purposes, and for treatment. He says:

"I do not often find it necessary to resort to anesthetics for the purpose of insuring quietude and annihilating pain in making these examinations, but if the examination is not satisfactory, and the diagnosis is important, I do not hesitate to render the patient completely insensible."

Hamilton is definitely committed to the plan of immediate reduction:

"Nearly all fractures present 3 principal indications of treatment, namely: To restore the fragments to their place as completely as possible; to maintain them in place; and to prevent or control inflammation, spasms, and other accidents. It ought to be regarded as a rule, liable only to rare exceptions, that broken bones should be restored to place as soon as possible after the occurrence of the accident."

His advice with reference to transportation of the injured may well be conceded as a forerunner to the instructions given by our transportation committee; namely, "Splint them where they lie," and "gentleness of handling."

Hamilton states:

"All that has been said in relation to the propriety of handling a broken limb gently when the surgeon is examining the position and character of the fracture, is equally applicable to the lifting and transporting of the patient to his bed, to the removal of his clothing, and to the general management of the limb before it is dressed. Rude or awkward manipulations by which needless pain is inflicted are not simply acts of wanton cruelty, but they are sources of inflammation, suppuration, and gangrene. It is difficult to state the precise manner in which the surgeon ought to proceed. Much will depend upon the circumstances of the case, something upon one's natural tact, and upon the amount of experience, but more, I think upon the natural kindness of heart, and social education. The man of refinement and sensibility will know instinctively how to proceed, and needs no instructions. They who lack these qualities can never learn, and it would be quite useless to undertake to teach them. I sincerely wish such men as these latter would find some more suitable employment than the practice of a humane art."

Those who believe that the so called Balkan frame and suspension methods are of recent introduction, would do well to note the Jenks fracture-bed frame described in Hamilton's text, as well as other suspension frames. The after-care of fractures with fracture beds containing provisions for bed pans was advocated by Hamilton, and he describes the Daniels fracture bed with such a provision.

In the section devoted to fractures, by Samuel D. Gross the elder, in his *System of Surgery*, published in 1882, we find the indication for treatment of fractures briefly summed up:

"The leading indications in the treatment of fractures are to procure reunion and to prevent deformity. It has been a much mooted question whether as a general principle a fracture should be set as soon as possible after its occurrence, or whether time should be allowed for the subsiding of the resulting inflammation. It certainly requires no great knowledge of the nature of the accident to discover that such cases should receive the earliest possible attention."

The first reference in a text on the subject of fractures to the Listerian method, we find in Gross's work:

"Whether carbolic acid, apart from the other means, recommended by Lister, is really any benefit in the treatment of those injuries is still a mooted question. A modification of the Lister treatment was introduced a few years ago in the New York Hospital by Professor Markoe, and has given most flattering results, only 1 death resulting in nearly 200."

More important, however, than any detail of treatment one can find is the advice of Gross with reference to fractures;

"There is no class of injuries which a practitioner approaches with more doubt and misgiving than fractures. They frequently involve consequences hardly less serious and disastrous to the surgeon than to the patient himself. If I were called upon to testify what branch of surgery I regarded as the most trying and difficult to practice successfully and creditably, I should unhesitatingly assert that it was that which relates to the present subject.

"I certainly know none which requires a more thorough knowledge of topographical anatomy. As for myself I never treat a case of fracture, however simple, without a feeling of the deepest anxiety in regard to its ultimate issue; without a sense of discomfort, as long as I am conscious that despite the most assiduous attention and the best directed efforts the patient is likely to be lame and deformed for life. A crooked limb, whether rendered so by injudicious treatment or not, is an unpleasant sight to the sensitive surgeon, in as much as it continually reminds him of his bad luck or want of success. I do not wish to be understood to say that it is always in his power to cure these accidents without deformity or impairment of function. Such a view would be contrary to experience and common sense. There are many cases of fracture which do not admit of any other results, however attentively or skillfully they may be treated."

The dissatisfaction expressed by Gross, Hamilton, and others led just a few years later to efforts to improve results. There appeared on the scene Arbuthnot Lane who Moynihan said was, "A man whose mind easily moves along new paths." As early as 1865, Lane began operating on fresh fractures, and for this purpose he used wire. His boldness is an inspiring example of an individual with courage to break away from tradition. He at least had the bolstering influence of the epoch-making work of the pioneers who had introduced anesthesia and of those who had paved the way for a clean surgical wound.

Surgical approach to the subject of fracture diagnosis and treatment had reached an *impasse* prior to the time of Crawford W. Long, in 1842, at which time he introduced ether anesthesia. We marvel at the heroism of the patients and the temerity of the surgeons of the past, who with brute force and "blind flying" attempted reduction of deformities following fractures in the days before anesthesia, and before the introduction of the x-ray. We also marvel at the boldness of the surgeons who before Pasteur and Lister attempted operative treatment of fractures.

As early as 1854 we find that Brainard condemned the use of wires and foreign bodies of every description as a means of promoting the formation of callus: He said: "It is a practice not founded on correct principles and is often dangerous." It should be recalled that this statement was made several years before Lister's application of Pasteur's discovery. Brainard however proved the greatness of his mind in the following statement: "Every method of treatment for ununited fractures appeals to experience in proof of its success."

Time marched on and Lane and Lambotte continued their pioneering break with orthodox methods. What reasons did Lane give for his desire to seek a change? From his own works published in 1905, we quote:

"Experience has taught me to regard the statements in anatomical and surgical work with strong suspicion. It was evident that the displaced fragments of a broken bone were never or hardly ever restored to their normal position, and the so called 'setting of fractures' was a myth. I made very extensive inquiries of medical men, and I was satisfied that the teachings contained in the text books, as to the possibility of restoring the form of broken bones, and the satisfactory results of their treatment were absolutely false."

These words of Lane were written in 1905, but he had evidenced his unrest as early as 1885. This was 10 years before Roentgen's discovery of the x-ray.

THE X-RAY

Evolutionary processes go on in the natural order. Man's appreciation of them waits for the unfolding of the secrets in the world about us, and for the practical application of the

scientific information thus unfolded. Within 1 year of Roentgen's discovery 49 books and more than 1000 scientific and clinical papers were published. The profession had been waiting for someone to lead them from darkness to light. Methods of reduction, which up to the advent of the x-ray had been dependent on accurate clinical observation, now had a valuable adjunct. American surgeons, like surgeons in all parts of the world, were quick to realize potentialities of x-ray for diagnostic purposes. The effect of the introduction of the x-ray on the professional mind is clearly stated by Cattell in 1896:

"No discovery in medicine has equalled its importance, since Pasteur, Lister, and Koch placed bacteriology on a scientific basis. Who a year ago would have dreamed of being able actually to see the displaced fragments in a Colles' fracture, to set the bone, to dress the arm and then examine the bone again through the wooden splint and bandages, and note whether or not the broken bones had been correctly approximated? The imagination of the reader is left to discover new fields of usefulness for this most wonderful and practical discovery of Professor Roentgen."

On April 8, 1896, in the *Electrical Engineer*, published in New York, the following announcement was made, with reference to the opening of the Post Graduate Hospital X-ray Department:

"Doctors to become cathodographers. Cathodography will shortly become one of the regular features of the Post Graduate Hospital, 20th Street and Second Avenue.

"The utility of taking x-ray pictures in surgery has been demonstrated so often, that hospital authorities have decided to set aside one of the smaller wards for that purpose; and they will equip it with Crookes tubes, Ruhmkorff coils, sensitized plates, and all other paraphernalia of the new art."

According to Glasser this was the first special Roentgen Department in the United States.

Philip Mills Jones, of San Francisco, and Edward A. Tracy, of Boston, expressed the sentiments of various sections of this country with reference to the new discovery and its usefulness:

"With no discovery within my recollection has the immediate and general excitement been so intense. The application of the x-rays in medicine has thus far been confined almost entirely to surgical diagnosis. Fractures and dislocations, though easy of diagnosis, are sometimes very puzzling. No matter what the natural ability, education or experience of the fingers, they may often be at fault; here, we have an agent that cannot err.

"The fractures and dislocations that have been examined with much profit by this means includes almost every large bone, almost every joint in the body, and no man who has availed himself of this aid in such cases will speak of it in any terms save those of the highest praise."

Edward A. Tracy, in 1897, said:

"The application of Roentgen's discovery necessitates the rewriting of the textbooks on fractures and dislocations. Facts, heretofore 'smothered by surmise,' are clearly set forth by the radiographs."

The United States Army made the x-ray an integral part of the Army medical equipment before 1898. In an article by W. C. Borden, published under the direction of the Surgeon General, George M. Sternberg, we read:

"Soon after the discovery by Professor Roentgen the Surgeon General of the Army supplied Roentgen-ray apparatus to several of the larger post hospitals. On the outbreak of the war with Spain and the establishment of the general hospitals, the most prominent and important of these hospitals and the three hospital ships, 'Relief,' 'Missouri,' and 'Bay State,' were supplied with similar appliances. The use of the roentgen ray has marked a distinct advance in military surgery."

One can say that the golden age of fracture diagnosis and treatment was born with the advent of the x-ray. After the advent of the x-ray reduction could be carried out with an accuracy not possible before. Let it be remembered that the x-ray did not add a principle but an aid in the carrying out of the fundamental conception of treatment.

That our predecessors realized their limitations is adequately expressed by Cooper, Malgaigne, Hamilton, Gross, Lane, and a host of others. The x-ray provided the opportunity for the surgeon to express himself either conservatively or radically. Conservatively, by the application of anatomical knowledge and physical principles, he could reduce a deformity definitely. When this was not accomplished he could safely apply direct exposure of the fracture site and make use of internal fixation for the purpose of assuring the reduction which was thus accomplished.

CONCLUSION

The discussions which have arisen since 1900 with reference to operative or non-operative treatment have had only one objective, to obtain the earliest and safest method of returning the injured to economic efficiency. In order to establish the truth, statistical studies had to be made, since none were available. These were not easily obtained. Statistics, which were presented in the early days, were favorable to one or the other method depending on the source and ability of the surgeons compiling them. It soon became evident that certain fundamental principles had to be applied if the greatest good was to be done. These principles are:

1. In general, conservative treatment applied along anatomical lines was the most successful in the average hands.
2. Certain fractures have to be operated upon routinely.
3. Direct surgical treatment of fractures should be done only by those qualified by training to operate and equipped with adequate armamentarium.
4. Proper hospital facilities are essential.

Improvements in x-ray facilities, better surgical technique, and new anesthetic agents have all contributed to the safety of surgery whenever indicated.

From the earliest times we find that the masters of surgery taught the value of reduction and immobilization. When to reduce, whether immediately or after variable periods of waiting for the swelling to subside, has provided many arguments. The gist of all discussions at the present time is that attempts at reduction should be made as soon as possible after the accident in simple fractures.

In compound fractures the debate still goes on. Some advocate immediate internal fixation and others direct skeletal traction and suspension. This is a question of experience and not evolution. The evolutionary step is the question of operation as an addition to our portfolio of safe procedures. The safety of this progressive step is dependent upon the qualifications of the surgeon and the environment provided. This question has been presented admirably by William O'Neill Sherman in a recent fracture oration. It need only be pointed out that direct, operative attack, which resulted from dissatisfaction, was a step in the development of fracture treatment.

In the evolution of the operative procedures by internal fixation many materials have been used and each lauded by enthusiasts. Time alone will answer all of the questions whether absorbable or non-absorbable material should be used, whether autogenous grafts of one kind or another are best; whether grafts are absorbed and act only as a splint and scaffold, or whether they remain permanently; whether one material is irritant, electrolytic, or not. All of these represent the passing show.

The principle of operating in selected cases is, however, a definite stage in the evolution of fracture treatment. Factors, which have made this step possible, are industrial developments, particularly chemical and metallurgical, as well as scientific achievement along bacteriological lines.

It should not be forgotten that fundamental principles of fracture treatment remain the same. They are early reduction and adequate immobilization. The axiom with reference to anatomical knowledge necessary for reduction must not be overlooked.

Will observers in the future credit our generation with progress in principles and practice or will we be charged with having spent our time idly discussing the polemics of who should treat fractures? Traumatic surgery is demanding more and more of our efforts, due to the ever increasing hazardous occupations and modes of transportation. The evolution of the fracture problem depends on continued search for truth and the utilization of all of the aids that scientific achievements place at our disposal for the benefit of the suffering mass of the human family. Let it not be said of our generation that we stagnated, or that we were bound by the adamantine force of the authorities of yesterday.

THE PSYCHIATRIST IN RELATION TO SURGERY

FRANKLIN G. EBAUGH, M.D., Denver, Colorado

SURGEONS, both as technical operators and as physicians practising the art of medicine, have often neglected an important phase of their science and art. They have failed to comprehend the *wholeness* of the personality and have been sidetracked into problems of cell or organ function. They have looked upon the sick person as an inert container of offending viscera and not as a reacting person with individual personality functions. Surgeons have failed to recognize that a patient is a unique collection of coordinated functions, an energy system in which every part while performing a special duty is, nevertheless, entwined with all the other functions; and that a change of function in one part is reflected in changes of functions in other parts and in the whole. It is the surgeon's job to remove or alter structures which are defective or diseased. His technical skill in accurate diagnosis and surgical interference is important, but he must know that his personality and the stage he provides may be more important.

What are the facts that will enable a surgeon to prevent or adequately care for the personality disorders which he meets in his work? How can he recognize these disorders if they are present? How can he avoid unnecessary surgery? How can he best prepare and care for the patient before, during, and after the operative procedure? Strangely enough, there is no need for any special equipment and no need for any complicated or cumbersome mechanical or electrical apparatus. The attitude and the facts necessary to deal competently with these problems are within the reach of anyone who wishes to have them and may be set forth as follows: (1) surgeon-patient relationships; (2) time and patience necessary to allow the sick person to tell his story so that one can understand the nature of the individual; (3) appreciation of the fact that not all pain, tenderness, or disability is organic in nature, and that removal of whatever is associated with the pain will prove to be rational therapy; (4) avoidance of delirious or toxic states by means of judicious chemical sedatives or adequate hydration and nutrition in the postoperative, convalescent state. These are attitudes and facts that should be adopted and utilized.

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

Surgeon-patient relationships. Tact in physician-patient relationships, sometimes called bedside manners, is a matter that is both endogenous and acquired. Unfortunately, in the development of bedside teaching in this country, students patterning their behavior on clinical instructors, even with the best intentions, do not deal with their patients in the most desirable way. Kahn and Powers considered the patients' emotional response to case discussion in a very lucid manner. Among other things they stated:

> "The idea has been developing in medicine that physicians are not treating diseases but are dealing with diseased human beings. Doubtless considerable progress has been made along this line and the fundamental idea seems to be well understood, but in clinical pedagogy, how is it possible to reconcile one's understanding of the patient as a human being with the teaching necessity of using him as 'material'?
>
> "In his preclinical years the student has been used to dealing with 'material' of different kinds in a very free manner; he had the opportunity to discuss everything perfectly freely with his teacher individually or in a group regardless of the physical presence of the 'material' concerned. When he comes into his clinical years he is confronted with a new situation. The connecting link between him and his teacher is no longer a guinea pig, an anatomical or pathological specimen, or a biochemical reaction, but another human being. The student is likely to throw himself on the patient with an eagerness similar to that which he displayed when taking hold of a preclinical 'material.' Even if it is assumed that a goodly number of students bring with them to their clinical years sympathetic understanding and much tact, the idea cannot be avoided that the development of their 'bedside manners' will greatly depend on the 'bedside manners' of their clinical teachers."

While these remarks were devoted to a consideration of the patient as he is used in teach-

ing hospitals, it applies to all patient-physician relationships as well. One need only recount the remarks concerning blood pressure readings which may frighten and obsess the patient for days, or the chance remarks that the heart is enlarged, the splenic notch palpable, this or that being better or worse. Under all circumstances one should avoid the practice of ill-considered, tactless discussion of a patient's problems within his hearing. Even with children, lack of tact is fraught with danger, because children often understand spoken language more adequately than adults believe and are able to interpret and evaluate even the most subtle nuances of sign language.

The patient should be comforted, and placed at his ease, and if a foreigner, some attempt should be made to supply a nurse, attendant, or relative who speaks his language. By all means, the untactful use of charts, specimens, roentgenograms, and technical bedside discussions should be avoided. In this respect nurses and attendants should be trained to maintain a sympathetic and tactful attitude in the patient's presence. A simple and understandable formulation of the problem should be given to the patient. This explanation should include reasons for hospitalization, diagnosis, and purpose of operative intervention. These data may be given in such a way that they become reassuring rather than alarming. The introduction to the operating room should be done wisely, again untactful waits in the surgical anteroom with its usual forbidding atmosphere should be avoided.

Brief personality analysis. The practising surgeon encounters far too many psychiatric problems in his daily work to permit him to refer all of them to the specialist in mental disorders, nor is this necessary or desirable. We believe that a planned study of the personality factors involved in the various problems greatly enhances the likelihood of successful therapy. Everyone agrees that emotional, social, situational, and kindred factors may cause complications in any somatic illness; but without some systematic knowledge it is difficult to deal efficiently with the mass of facts accumulated by investigation. How, then, may the surgeon equip himself with the information necessary to enable him to recognize, interpret, and treat the personality disorder that he may meet in his practice? Whether or not the patient is mentally ill before an operative procedure or may become so during or after such a procedure, is not as important as the interested attitude and factual groundwork of the surgeon. We believe that, if surgeons took the time and expended sufficient energy to investigate the past history of the patient, the relevant family data, the origin and development of present illness, the underlying personality of the patient and the signs and symptoms which may appear more or less to be related to the surgical complaint, there would be fewer unnecessary operations, and if intervention were indicated, the patient would be better prepared for it and would experience a much more tranquil convalescence. Incomplete examination and inadequate diagnostic study without evaluation of personality make-up may lead to unnecessary surgical intervention. Let the following case abstracts exemplify what is meant:

CASE 1. E. F., a white female, 27 years of age, single, was admitted to the medical outpatient department of the Colorado General Hospital on January 11, 1937, and was referred to the Psychiatric Liaison department on March 2, 1937. Her complaints were sudden, abrupt pains all over her body, puffing of various regions of the body, nervousness and depression of mood. Previous operative history was as follows: puncture of left ear drum at 9; tonsillectomy at 10; re-operation of tonsils at 13; nasal septum operation at 13; radium treatment for inward goiter at 13; appendectomy at 14; drainage of gall bladder at 22; puncture of cyst of right ovary at 22; cholecystectomy and right ovariectomy at 23; thyroidectomy at 25; hemorrhoidectomy at 26. Physical, neurological, laboratory and psychiatric examinations were completed and a diagnosis of a tense, depressed, insecure, hysterical personality with somatic conversion symptoms was established. Treatment was both supportive and causal with special care to point out the significance of the emotional factors of domestic incompatibility, worry over increasing age, unemployment and fear of invalidism. Inasmuch as it was necessary for the patient to return to her home in a distant part of the state, only 2 interviews were possible, during which time the patient was able to appreciate the rôle of the emotional factors in her present complaint.

CASE 2. The patient was a 21 year old, single, white girl, who entered the hospital with the family physician's statement: "Hyperthyroidism and ex-

ophthalmic goiter for 11 years, exophthalmos, fine tremor, enlarged thyroid, tachycardia." Examination disclosed an anxious, tense girl complaining of shortness of breath, pounding heart, and choking sensation in the mid-neck region. Her eyes were prominent with some exophthalmos, thyroid was not palpable, resting pulse rate was 84 and blood pressure 100/72. The patient had had an increased appetite but lost 5 pounds in 2 months and was sensitive to cold. The basal metabolism rate showed a minus 18 and minus 24. She had been referred to the hospital for psychiatric opinion by surgeons who rejected the diagnosis of toxic goiter. The patient came from a family in which the incidence of illness was high. She had never been able to carry through plans and responded to failure with temper tantrums and other symptoms. There were marked school difficulties at the age of 10 when she was told by her family doctor that she had a goiter. Her life since had been poorly organized and unproductive of needed satisfactions. With each failure the patient had fallen back on medical support and "goiter." The present illness appeared in a setting of disappointment incident to her being dropped from a beauty culture school after seriously burning a customer. With psychotherapy the patient developed insight, was markedly improved, and left the hospital to enter work consistent with her abilities.

CASE 3. A. P., 29 years of age, was a white female, married, and the mother of a 4 year old child. She complained of constipation, a drawing sensation in the epigastrium, nausea, and marked belching after meals. Upon examination there was indefinite tenderness in the epigastrium without rigidity. The symptoms had come on 4 years previously. X-ray examination showed a duodenal deformity consistent with ulcer; free hydrochloric acid 4 per cent, total 11.5; occult blood 4 plus in stool. Laparotomy was performed and nothing was found. The study showed the patient to be a rather independent person who had always supported herself. Soon after her marriage she became pregnant and had to give up her job and depend upon her husband's smaller uncertain income. She resented this situation, became anxious about it and developed the above symptoms after the child which increased her responsibilities and accentuated the financial difficulties. When the diagnosis of ulcer was made the patient became body conscious and insecure and this has continued. Psychiatric study and therapy resulted in notable improvement.

These case histories are cited to stress the point that adequate investigation of the endowments and experiences of the personality will go far to prevent unnecessary surgical intervention. Not only will there be fewer unnecessary surgical operations, but fewer residual states of *psychic* or other invalidism in which the patient usually seeks an outlet for emotional conflict in the form of bedfastness, an interminable series of operations, hypochondriacal concern over various system functions, and so on.

Psychosomatic relations. Much has been accomplished since Hawthorne remarked in the *Scarlet Letter*, "A bodily disease which we often think of as a thing apart and separate, may after all, be but a symptom of an illness in the spiritual part of our nature."

The recent reviews of Dunbar and Wittkower have aided in drawing attention to some of the difficulties encountered in the study of psychosomatic relations. More specifically, the psychogenic aspects of thyrotoxicosis (1, 7a, b), and the disorders of the gastro-intestinal tract (7b, 9a, b, 11), have been and continue to be sources of fruitful investigation. In the evaluation of the psychogenic factors 2 elements must be considered: first, the underlying personality make-up, and second, the exciting factor which may be impersonal, personal, or interpersonal.

It is hoped that the recent introduction of psychiatry into the general hospital will serve as a means of teaching physicians and students the need for a more integrated approach to the sick person, as well as offering a fertile ground for further study of the psychogenic aspects of various clinical syndromes (5a).

Psychiatric complications in the postoperative phase. In previous communications (5b, c, d), the author has pointed out the most frequent psychiatric complications in surgery and in general practice. We have discussed the courtesy and tact of the surgeon in the pre-operative period. The rôle of the operation, itself, may be an important factor in precipitating or intensifying depressive or anxiety states.

Taylor, a surgeon, corroborated our impression that a disproportionate amount of emotion is aroused in any procedure which concerns the genital organs. Regarding genito-urinary surgery in the male he stated:

"Many changes may take place in the scrotum. Some of them are of little consequence, some may be disastrous. Not the least thing to be considered is the mental condition that often accompanies any pathological condition affecting the genitals. It is often found necessary to correct some trifling disorder that otherwise would be ignored, to cure a neurasthenia that is wrecking a business career. A

man will bear with equanimity a wen on his hand or a wart on his nose but a small varicosity in the scrotum will keep him awake at night and depress him during the day. I have operated upon many varicoceles to cure a malady that was above the neck."

One should also mention the psychic trauma and concern over the frequent pelvic evisceration in the female and amputation of limbs in either sex. However, the most frequent complications are those encountered in the postoperative phase (2, 12). They may be due to the following: neglect in immediate postanesthetic care in respect to assurance, encouragement, and re-orientation; Preu and Guida recently described the *modus operandi* of postcataract panics; toxic and infectious complications leading to deliriums and other symptomatic psychoses, caused by the unwise choice of an anesthetic, etc.; lack of adequate fluid and nutritive factors causing dehydration, ketosis, avitaminosis; injudicious chemical sedation intensifying pre-existing delirious states or actually provoking drug delirium; and failure to inform the patient as to what was done and the result obtained.

The symptomatology of the complications varies in form and content. The following outline may be of value:

Pre-operative. (1) Pre-existing instability, neurosis or psychosis intensified by hospital admission; (2) development of fear or panic state due to inadequate or injudicious preparation (ill-considered, tactless remarks, demonstrations, etc.).

Post-operative. (1) Psychoneurotic symptomatology (from monosymptomatic hysterical syndromes to the more diffuse anxiety states); (2) symptomatic psychoses (deliriums due to chemical sedation or to toxins, infection, or malnutrition); (3) the frank psychoses (mania, various types of depression and schizophrenia).

Since drugs definitely increase the tendency to deliriums, a short discussion of the latter will be in place. A delirium may be defined as a disturbed mental state in which disorientation, a predominating effect of fear, and usually a tendency to hallucinations are present. These are closely connected with somatic conditions in that they are dependent upon, or associated with, intoxication, drugs or poisons, nutritional disturbances, circulatory phenomena, and metabolic disorders. These disturbances produce temporary brain changes which are in the nature of edema, or the obscure concomitants of fever, dehydration, and acidosis. The occurrence of delirium should not be considered merely incidental to the principal disease picture. It is a complication that may, and in a great percentage of cases does, interfere with the treatment of the clinical problem in hand. To say the least, it increases the suffering, prolongs the duration of the illness, and may necessitate special hospitalization of the patient; it may even be a personality disorganizing factor of such magnitude as to produce chronic invalidism and incompetency. The delirious patient, befuddled, disoriented, hearing threatening voices, misinterpreting situations, overwhelmed by misgivings and fear and given to action, is in potential and acute danger of injuring himself and even of losing his life by jumping from a window. A very large percentage of deliriums either are preventable or can be ameliorated if recognized early.

TREATMENT

Treatment must, of necessity, be preventive as well as causal and supportive. The following points may be of value in stressing treatment possibilities:

1. It is most important to look upon the sick patient as a variously integrated personality rather than a caricature of a diseased viscus. This means that in addition to adequate physical, neurological, and laboratory examinations an attempt should be made to discover and interpret the development and significance of the symptomatology from the points of view of the personal and interpersonal aspects as well as the more tangible impersonal or somatic. This will include a careful differential diagnosis of those physical disorders which are frequently simulated or complicated by psychogenic factors, as thyrotoxicoses, gastric and duodenal ulcers, colitides, etc.

2. Simple, understandable and sympathetic formulations should be given to the patient. These should explain the nature of the immediate hospital environment, the nursing procedures, and the various examinations.

3. One should avoid untactful remarks, unnecessary phrases or the demonstration of charts and roentgenograms which may startle or frighten the patient.

4. One should take care to avoid overdosage of chemical sedatives, to be aware of susceptibility to the various drugs used in basal anesthesia, and to use hydrotherapy whenever possible.

5. Toxic and infectious complications should be prevented by due attention to fluid balance and to an adequate nutritive state.

6. In unstable individuals, particularly in the psychoneurotic group, operative intervention, in all but emergency conditions, should be postponed. It is in this group of problems that one meets the all too frequent operation for the removal of adhesions. A careful scrutiny of the presenting complaint from all points of view, including that of a brief personality appraisal, will decrease the number of unnecessary operative procedures.

7. If operative intervention is indicated in a patient who is manifestly neurotic or psychotic, psychotherapeutic measures should be instituted, if possible, before and after the operation.

SUMMARY AND CONCLUSION

The attention of the surgeon has been called to the following needs: tact in surgeon-patient relationship; thorough and adequate personality analysis of each patient; appreciation of the rôle that emotional conflicts play in creating, complicating, or masking somatic disease; and the avoidance of postoperative complications by the maintenance of an adequate fluid balance, nutritive state and the judicious prescription of chemical sedation.

This has been a most welcome opportunity to review a few major problems which need the mutual co-operation of the psychiatrist and the surgeon. Each is a practitioner of the healing art upon the patient, who should not be thought of as a mechanized collection of organs, but as a reacting person with individual personality functions. It is hoped that a wider dissemination of this point of view will lead to greater understanding and to further perfection of methods of diagnosis and treatment in the field of our common interests.

REFERENCES

1. Billings, E. G. Anxiety syndrome. Colorado Med., 1937, 34:14.
2. Cobb, S., and McDermott, N. T. Postoperative psychoses. Med. Clin. N. America, May, 1938, 22:569.
3. DaCosta, J. D. Modern Surgery. 10th ed. Philadelphia: W. B. Saunders Co., 1931.
4. Dunbar, H. F. Emotions and Bodily Changes. New York: Columbia University Press, 1935.
5. Ebaugh, F. G. (a) Psychiatric facilities in the general hospital. Am. J. M. Sc., June, 1938, 195:833; (b) The Toxic Organic Reaction Types. Oxford Medicine. N. Y.: Oxford University Press, 1936, 7; (c) Psychiatric complications in surgery. Bull. Am. Coll. Surgeons, 1937, 22: 153; (d) Frequent psychiatric complications in general practice. Am. J. M. Sc., August, 1937, 194:243.
6. Kahn, E., and Powers, G. F. Bedside teaching. Consideration of the patient's emotional response to case discussion. J. Am. M. Ass., August 29, 1936, 107: 639.
7. Moschcowitz, E. (a) The nature of Graves' disease. Arch. Int. Med., October, 1930. 46:610; (b) The psychogenic origin of organic diseases. New Eng. J. Med., April 4, 1935, 212:603.
8. Preu, P. W., and Guida, F. P. Psychoses complicating recovery from extraction of cataract. Arch. Neurol. & Psychiat., October, 1937, 38:818.
9. Sullivan, A. J. (a) Psychogenic factors in ulcerative colitis. Am. J. Digest. Dis. and Nutr., 1936, 2:651; (b) Emotion and diarrhea. New England J. Med., Feb. 13, 1936, 214:299.
10. Taylor, C. B. The scrotum. South. M. J. 1933, 26: 187.
11. Tillotson, K. J. The psychobiological approach to gastro-intestinal disorders. Am. J. Digest. Dis. and Nutr., 1937, 4:682.
12. Washburne, A. C., and Carns, M. S. Postoperative psychoses. J. Nerv. & Ment. Dis., November, 1935, 82:508.
13. Wittkower, E. Studies on the influence of emotions on the functions of the organs. J. Ment. Sc., 1935, 81:533.

THE TREATMENT OF OTITIC MENINGITIS DUE TO STREPTOCOCCIC INFECTION BY SURGERY AND SULFANILAMIDE

CARL H. McCASKEY, M.D., F.A.C.S., Indianapolis, Indiana

ALMOST unbelievable is the improved prognosis in streptococcic meningitis brought about by the introduction of sulfanilamide and its derivatives. Scarcely 3 years ago G. Domagk first reported this valuable form of chemotherapy, and yet the numerous enthusiastic reports in the literature already indicate a vastly improved future for streptococcic meningitis therapy (3, 16, 23, 33, 35, 41). Our pre-sulfanilamide records, as well as those of others, show a depressing mortality of close to 100 per cent for streptococcic meningitis, the type or the earnestness of treatment notwithstanding; whereas the previously mentioned articles indicate an encouraging 20 to 45 per cent mortality. The cases to be reported here, also, substantiate this more hopeful outlook.

The term otitic meningitis implies, of course, a meningitis resulting from a pathological auditory apparatus. Its significance to the otolaryngologist is best shown by a series of autopsies including 110 cases of suppurative meningitis in which approximately three-fourths were shown to have otitic infection as the primary etiological factor (11). To establish such a diagnosis clinically one must rule out by careful history and physical examination (1) any infectious process, local or general, producing the meningitis and antedating the otitis media, or (2) any intercurrent infection which is accompanying a suppurative otitis but which in itself accounts for the meningitis. Not infrequently an ear infection, throwing out organisms to produce a meningitis, is overlooked or more often considered non-surgical because of a lack of clinical or x-ray findings. The practising physician must learn the lesson vividly portrayed in recent years at the Indiana University Hospitals by 5 streptococcic meningitic autopsies, 3 of which disclosed unoperated upon unilateral or bilateral mastoiditis and otitis accounting for the meningitis.

Our desire is to describe 7 cases of meningitis treated with sulfanilamide and surgery as indicated. Four had hemolytic streptococcic meningitis, 1 a serous meningitis accompanying an acute streptococcic otitis and mastoiditis, 1 a serous meningitis with a Gram positive bacillary otitis and mastoiditis, and 1 a meningitis due to an unknown Gram negative bacillus. It seems warranted first to emphasize briefly salient points concerning streptococcic otitic meningitis and the chemotherapeutic agent, sulfanilamide.

ETIOLOGY AND PATHOGENESIS OF STREPTOCOCCIC OTITIS MENINGITIS

Obviously by definition such a meningitis results from the entrance of streptococci into the cerebrospinal system from an otitic focus. Such a meningitis tends to be fulminating; however, the actual speed of development depends largely upon the pathway of infection (8).

Pathogenetically, the organisms may travel from the ear to the meninges by direct extension via the eighth nerve, through persisting sutures or dehiscences, through the aqueductus cochleæ or ductus endolymphaticus (27), or through an osseous discontinuity resulting from trauma or operative procedure. The spread may be hematogenous, but probably most common is the propagation by thrombophlebitis from an area of osteomyelitis or periostitis produced by an expanding middle ear infection (10). A true streptococcic meningitis will be suppurative in type although one may have a serous or sympa-

From the Surgical Department of Indiana University School of Medicine through the Otolaryngological Division.
Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

thetic meningitis with turbid spinal fluid under increased pressure, increased cell count (usually predominantly polymorphonuclears), and negative albumin, globulin, smear, and culture. A localized suppurative meningitis with an accompanying serous meningitis is also possible.

DIAGNOSIS

The history and the physical findings of meningeal irritation plus the laboratory report of the prompt diagnostic spinal tap usually lead to a diagnosis. One must bear in mind and differentiate by the above procedures other possibilities such as meningismus, which usually accompanies acute systemic infections, encephalitis, poliomyelitis, and benign lymphocytic chorimeningitis, acute syphilitic meningitis, subarachnoid hemorrhage, localized suppurative meningitis, and serous meningitis (46). The latter 2 conditions and a generalized suppurative meningitis tend to come into the hands of otolaryngologists because etiologically there is often an underlying otitis, mastoiditis with associated epidural abscess, or sinus thrombosis.

The spinal fluid in streptococcic meningitis is characteristically turbid under increased pressure, elevated cell count, and polymorphonuclears predominating as a rule. The cloudiness is produced by the resultant irritative tissue exudation (10) thereby serving partly as a guide to the case's progress. The albumin, globulin, and lactic acid are variably increased. A typical meningitic gold curve will usually be obtained. Serology, smear, and culture are valuable in differentiation; and the streptococci will eventually be found thus if they have broken out of the original focus in sufficient number and if permitted to multiply. Degenerative forms of streptococci and certain other pathogenic organisms may appear Gram negative.

Other laboratory work such as urinalysis, blood count, and the like must be considered in evaluating a case. To follow a patient's progress adequately one can follow the suggestions of Maxwell in the management of otitic sepsis. He advises observing frequent pulse, respiration, and temperature readings, following daily blood counts, urinalyses with centrifugate smear study, and blood cultures, examining the patient often, and ordering chest x-ray examination, etc., when indicated. The good clinician never forgets that the sick patient, as one with meningitis for example, may contract some other pathology to complicate the picture.

Streptococcic meningitis calls for prompt diagnosis and treatment. One must not delay in performing a diagnostic spinal tap, carrying through any surgical procedure that is indicated, and instituting other therapeutic measures. A few hours of procrastination may greatly affect the prognosis. Persistent headache and developing meningeal irritation in the presence of otitis and mastoiditis calls for immediate action, particularly so with a sclerotic or poorly pneumatized mastoid in which the easiest pathway for the infection is toward the meninges.

TREATMENT

Therapy in streptococcic meningitis, as noted, demands prompt, logical action. Here, as in numerous phases of medicine, one finds a wide variation in the recommendations proposed by different successful clinicians. An article late in 1937 (27) reviewed extensively the multitude of therapeutic procedures which have had their day or are now in vogue. Nevertheless, most of the recent literature indicates that the majority subscribe mainly to the fundamental objectives of (1) eradicating the etiological focus, (2) draining the cerebrospinal fluid regularly and frequently, (3) neutralizing infection with serums and chemotherapeutic agents, and (4) supporting the patient conscientiously.

Removal of the primary focus usually calls for surgery, which must be adequately complete for each particular case. Whether one does (1) a simple mastoidectomy, (2) a radical mastoidectomy, (3) an uncovering or opening of the lateral sinus, (4) a wide exposure of the dura, (5) a labyrinthotomy, or (6) a revision of the entire operative field when the meningitis follows surgery, depends upon the case history, examination, and findings at operation. The introduction of sulfanilamide has been hailed by some as a possible substitute for surgery in these cases. Far more logically, sulfanilamide should serve as an adjunct to

surgery rather than as a substitute for localized drainage. Philosophically, Lewy states, "The elimination of a large amount of surgery now done in otogenic meningitis may be in the offing, but it would still seem advisable to operate until our diagnostic skill is improved, particularly so with chronic ears."

Exposure of the dura to the full extent of involvement has become a widely used procedure, advocated by many. Some (14), on the other hand, are not convinced of its efficacy, and almost all are opposed to opening the dura unless definitely indicated. In such a case it is wise to close over the dural gap with fascia, muscle, or some other tissue so as to avoid a persistent connection with the pneumatized air cells which might serve as a pathway for future infection.

For cerebrospinal fluid drainage the tendency is toward simple, regular lumbar punctures at 8 to 24 hour intervals depending on the amount of intraspinal pressure and cisternal or ventricular taps in the event of block. Lumbar puncture was first introduced in 1890 by Wynter, and cisternal drainage in the following year by Ballance (18). Procedures described since that time have tended to be more radical, a recent example of which is Kubie's method of forced drainage. These more formidable procedures are frowned upon to a great degree (18, 23, 35).

Supportive care plays a major rôle in every streptococcic meningitis recovery. The usual severity of such a case demands intravenous fluids and frequent transfusions according to the indications as well as absolute physical and mental rest. Sedation permits calmness and conservation of energy; an easily assimilative and eatable diet plus ample fluids allow build-up and support. Stimulants of general metabolism and hematopoiesis, particularly leucocytosis, can be of value. Atkinson stresses these points in his pre-operative management of acute streptococcic mastoiditis; but unfortunately with otitic meningitis one cannot wait for mastoid localization, as he advises in treating mastoiditis *per se*, since most of the value derived from surgery is obtained early in surgery.

Fighting the infection by means of serums and chemotherapeutic drugs has made the greatest recent advancement because of sulfanilamide's introduction. The many types of serum offered on the market are of variable value in therapy. Autogenous serum intraspinally has been recommended highly by some (27), particularly in a slowly responding case. They reason that the blood has attained a fairly high titer by that time; and since the choroid plexus tends to prevent the passage of immune bodies, intrathecal administration of the blood serum should raise the titer in the cerebrospinal fluid.

The therapeutics of sulfanilamide have received bountiful attention subsequently to its advent into medical literature. It probably has shone most brightly in the treatment of streptococcic meningitis. Recommended dosage varies to a moderate degree, but a review of the vast number of reported cases in the literature suggests a considerable amount of agreement among clinicians. Oral and rectal administrations of sulfanilamide are preferred although an 0.8 per cent sulfanilamide solution given subcutaneously and intramuscularly, or subcutaneous prontosil injections, are noteworthy in the vomiting or comatose patient. Intravenous sulfanilamide usage is advised by only a few men and intrathecal administration of the drug is discouraged by Adolph and Lockwood, and others (3 et al.) who reason, that because the streptococci are doing their damage deep in the meninges rather than out in the cerebrospinal fluid, sulfanilamide placed therein can have little effect. Furthermore, the spinal fluid concentration of sulfanilamide approximates closely that of the blood despite the method of administration.

Dosage has more or less regulated itself to around three-fourths of a grain of sulfanilamide per pound of body weight taken orally at 4 to 6 hour intervals, 5 to 50 cubic centimeters of 0.8 per cent sulfanilamide solution or prontosil parenterally at 6 hour intervals or longer depending on the case. Simultaneous dosage of sodium bicarbonate orally or sodium lactate intravenously, if the patient is unable to take alkali by mouth, will combat the acidotic tendency which often develops. We and many others (3, 5, 35) have noted the rapidity with which a patient with impaired renal function will build up a blood sulfanilamide concentra-

tion. This factor plus the several toxic manifestations customary with this drug group must always be borne in mind regardless of the dosage being used.

Sulfanilamide has been proved to be of value in treating experimentally induced streptococcic meningitis in white rats (2), rabbits, and monkeys (25). Other recovered cases of otitic streptococcic meningitis treated clinically with sulfanilamide and mastoidectomy as indicated are cited in the recent literature by authors other than those mentioned (13, 17, 38, 42, 44, 45). Among numerous other articles are complete recoveries reported for a case of otogenic meningitis due to an anaerobic Streptococcus hæmolyticus beta (43) and a case due to a non-hemolytic streptococcus (30). Experimentally in monkeys and rabbits (25) and clinically it appears encouraging in pneumococcic meningitis when used conjointly with specific type serum (3, 35), and may prove helpful in the future in treating meningococcic and influenzal meningitis. The drug's great success in otogenic meningitis may warrant its usage in the future as an empirical treatment, despite negative spinal fluid cultures (26).

PHARMACOLOGY OF SULFANILAMIDE AND ITS DERIVATIVES

Of chief interest is the mode of action of sulfanilamide about which there has appeared much ado in recent literature. Long and Bliss (28), American pioneers in this momentous therapeutic advancement, first described the effectiveness of the drug as being due to bacteriostasis which in turn promoted phagocytosis by the polymorphonuclear cells early in treatment and by the monocytes later. Further experimentation by these workers (29) strengthened their original conclusions and promoted the theory that retarded streptococcic proliferation lessened the output of leucocidins and similar toxic products, thereby aiding phagocytosis.

Based upon widely varied clinical and experimental observations, other men (22, 25) have arrived at conclusions basically similar to those of Long and Bliss. However, some have maintained that the primary effect is a neutralization of the organismal toxins, i.e. aggressins, leucocidins, and other antiphagocytic substances (36, 37). To improve the tenability of this viewpoint Osgood and Brownlee (36) remarked: "Clinically its (sulfanilamide's) rapid alteration of the course of erysipelas, streptococcic meningitis, etc., is more easily explained on the basis of neutralization of toxin than on the basis of a bactericidal action." Contradictorily, others (20) disclaim any antitoxic mode of action but instead stress the slowing effect on streptococcic multiplication and metabolism which in turn accounts for decreased toxin formation. Still others (2, 45) have published their experimental work disproving the theory that increased phagocytosis plays a part in sulfanilamide action. Working with white rats and mice they could show no evidence of increased phagocytosis by either the leucocytes or cells of the reticulo-endothelial system. Clinical observation indicates that the effect of the sulfanilamide apparently is independent of the leucocytes since a developing leucopenia is the rule and there occurs no proportionate increase in the polymorphonuclear cells (7). Hedging on the issue, we are inclined to believe that sulfanilamide furthers bacteriostatic, bactericidal, and antitoxic action, thus reinforcing the body's own mechanisms to eradicate certain types of infection.

As to sulfanilamide's effective concentration, the use of human marrow cultures showed a 1:100,000 concentration to be as efficient as any against the streptococcus (36). Now, such a proportion is easily obtained by the accepted administration of sulfanilamide and can be maintained by doses at approximately 6 hour intervals, because in the average case the maximum blood concentration is reached in 4 to 6 hours. Within recommended dosage the blood sulfanilamide percentage will be roughly proportional to the amount of drug given provided no impaired urinary excretion exists, as noted. Hepatic damage or moderately severe anemia likewise warrants extra precautions to prevent dangerous concentrations. Noteworthy, also, are a few observations concerning excretion (1): (1) Sixty to 70 per cent of absorbed sulfanilamide leaves via the urinary tract; (2) in the lactating mother the milk carries a higher concentration

of sulfanilamide than does the blood due to a concentrating power of the mammary gland; and (3), the drug, when given to a pregnant woman, reaches the placenta and may account for increased fetal mortality and morbidity.

DERIVATIVES OF SULFANILAMIDE

Although vast numbers of sulfanilamide derivatives have been tried experimentally and clinically, the original product appears far ahead at present in effectiveness and applicability. The derivative running a close second is prontosil and its concomitant usage with sulfanilamide receives considerable comment in the literature. Neoprontosil has been found to be apparently less toxic clinically and a worthy substitute for sulfanilamide although absorbed more slowly (5). The same clinical series found di-methyl-di-sulfanilamide less toxic in general usage except for a peripheral neuritis developing in approximately 6 per cent of the cases. This drug was, therefore, not used further. Neoprontosil yields only one-fourth its weight in sulfanilamide so that Applebaum feels that its therapeutic action results from some other factor besides sulfanilamide. He recommends its use orally as well as a combination therapy with the less complex sulfanilamide.

Enumeration of further instances of satisfactory sulfanilamide therapy as reported in the literature includes cases of erysipelas, pneumonia, scarlet fever, streptococcic sore throat, adenitis, urinary infections, sinusitis, and many others (17 et al.). Of almost unquestionable value is its administration in streptococcic otitis media and mastoiditis, particularly in the prevention of complications therein (2).

On the other hand an attempt to clear up several cases of positive streptococcic throat carriers proved disappointing (21). A still more varied application of the drug is found in the recent reported satisfactory treatment of ulcerative colitis with neoprontosil (5). No doubt, in final analysis, such ardent widespread application of the drug will be unwarranted but at present no one can be criticized for trying it in certain conditions, particularly those for which past therapy has proved discouraging.

TOXICITY OF SULFANILAMIDE AND ITS DERIVATIVES

Medical history relates again and again the consequential disasters which almost invariably follow the introduction and extensive application of a drug greeted with such enthusiasm as was sulfanilamide. Complications therewith obtained a head start through the unfortunate "elixir of sulfanilamide," which later was proved to have brought about so many fatalities because of its solvent, diethylene glycol (15). No doubt, to prevent such mishaps any future therapeutic agent should receive exhaustive experimental tests for toxicity, compatibilities, and the like, prior to its acceptance by the medical profession; and yet, experimentation progresses cautiously and painstakingly, whereas enthusiastic therapy too often runs hog wild.

Even though the drug has many toxic manifestations, fortunately most of them are not serious; regrettably, the mechanisms producing many of them are not known. Experimentally, with mice, rabbits, dogs, and human marrow cultures, no permanent tissue damage could be demonstrated after an average dose (31, 36). Possible toxic manifestations are, namely, malaise, anorexia, nausea, vomiting, tinnitus, dizziness, mental confusion, cyanosis, fever, abdominal cramps, diarrhea, hepatitis, nitrogen retention dermatitis, anemia, thrombocytopenia, and perhaps others. The "drug fever" usually appears after a week to a week and a half of therapy. As to the incidence of these, it is impossible to formulate any complete statistics; however, in a series of 114 consecutive cases of beta-hemolytic streptococcic infections treated with sulfanilamide by Hageman and Blake (17) such toxic complications occurred in 56 per cent, with cyanosis being by far the most common. Whether some of these in the future can be prevented in a similar manner, as is acidosis with its resultant cyanosis now avoided by the concomitant administration of alkali, rests with future experimentation. Some acetyl sulfanilamide is produced from absorbed sulfanilamide, and data indicate that it is more toxic than sulfanilamide itself (31).

The toxic reactions enumerated are soon relieved almost invariably by discontinuing

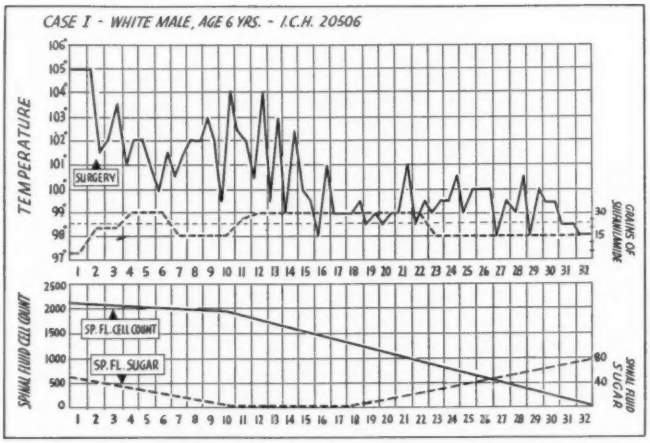


Fig. 1. Case 1. A hemolytic streptococcic meningitis resulting from an acute hemolytic streptococcic otitis media and mastoiditis.

the sulfanilamide. Graver complications, which appear more like drug idiosyncrasies, happen all too frequently for comfort, judging from the numerous reports in the literature. Six or more cases of fatal granulocytopenia have been reported due to sulfanilamide or prontosil; these reports demonstrated maturation arrest in the bone marrow and phagocytosis of iron pigment, representing a hemolytic type of anemia (6, 40). At the Indiana University Hospitals we have experienced only one such case which ended miraculously in recovery.

Another serious complication, acute hemolytic anemia, occurs occasionally and, like most drug idiosyncrasies, develops as a rule with surprising rapidity. Judging from the several cases cited in the literature (19, 24), one can expect satisfactory recovery after withdrawal of the drug and one or more transfusions. Much more commonly a patient develops a maculopapular dermatitis 1 to 3 weeks after the first dose of sulfanilamide which clears with some desquamation over a period of days to weeks after the drug is discontinued. Other toxic symptoms tend to precede the skin rash so that this toxic manifestation can frequently be prevented by reducing the dosage, or, if possible, by stopping the drug's administration. Severe cases of dermatitis medicamentosa from sulfanilamide have been described during the past year (12, 34, 39).

This discussion concerning sulfanilamide toxicity emphasizes the necessity for continued observation of the patient in order to note the appearance of any early toxic manifestations. The latter should serve as danger signs to promote a closer check on the patient's general condition, hemoglobin readings, and blood counts. Beware of a developing leucopenia or anemia!

PRESENTATION OF CASES

The accompanying tables represent in the upper graph the patient's temperature course, the day when surgery and transfusions were performed, and the daily sulfanilamide dosage. The lower graph in each table shows the spinal fluid cell count, the spinal fluid sugar, and the blood or spinal fluid sulfanilamide concentration in milligrams per 100 cubic centimeters of blood.

Four cases of proved hemolytic streptococcic meningitis were treated with mastoid surgery as indicated and sulfanilamide.

Case 1. No. 20506, L. McC., male, white, aged 6 years. The patient, an emergency case, was brought to the Indianapolis City Hospital on June 15, 1938, with right aural pain and drainage, high temperature and irritability. Earache had begun 4 days before and spontaneous drainage the next day.

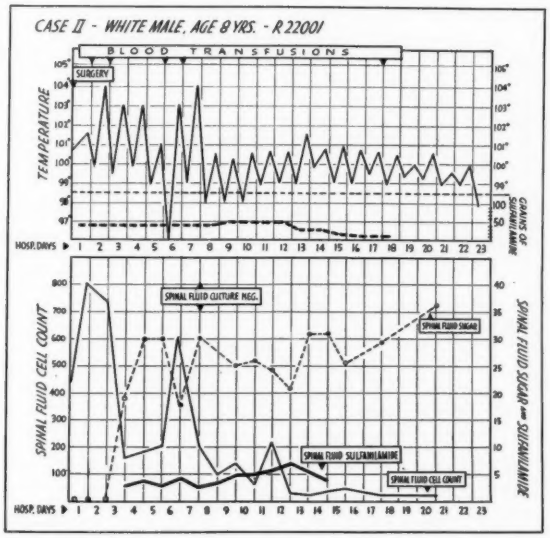


Fig. 2. Case 2. An acute hemolytic streptococcic meningitis, mastoiditis, and otitis media complicating scarlet fever.

Symptoms grew progressively worse. The past history was negative except for frequent bilateral suppurative otitis. Examination on admittance showed the patient to be acutely ill and irrational, with right ear drainage, right mastoid tenderness, infected tonsillar crypts, dental sordes, neck rigidity, and absent patellar reflexes. On the day of admittance a right mastoidectomy was performed. Pus was found together with extensive bone necrosis. The dural plate of the middle fossa was involved, and a wide exposure of the dura as well as of the lateral sinus was performed. Sulfanilamide was administered rectally and later orally. Frequent spinal fluid drainage was performed and general supportive measures used. The patient had a good recovery and was discharged on July 18, 1938. The laboratory findings were as follows: white blood count on admittance 19,400; red blood count 3,800,000; urine negative except for few hyaline casts and pus cells; spinal fluid cell count 2,290 with elevated globulin and lowered sugar; 3 positive hemolytic streptococcus cultures; x-ray of right mastoid showed increased density and sclerosis. The final diagnosis showed (1) mastoiditis and otitis media, acute right Streptococcus hæmolyticus; and (2) meningitis, Streptococcus hæmolyticus.

CASE 2. No. 22001, J. F., male, white, aged 8 years. The patient, an emergency case, was brought to Riley Hospital on March 3, 1938, with headache, draining right ear, backache, and occasional vomiting. The onset had occurred 23 days before with bilateral earache; 2 days later scarlet fever rash was noted; and bilateral aural drainage started 3 days afterward. Sulfanilamide was administered by a local doctor. After 1½ weeks frequent headaches occurred. This and other symptoms were severe for the last 2 days before admission. Two years previously both ears had been draining. Examination on admittance showed a desquamating skin, purulent right otitis, and right mastoid tenderness.

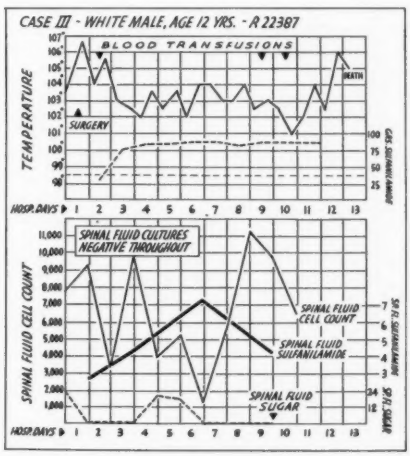


Fig. 3. Case 3. An acute hemolytic streptococcic meningitis following a unilateral mastoiditis and terminally developing a suppurative labyrinthitis.

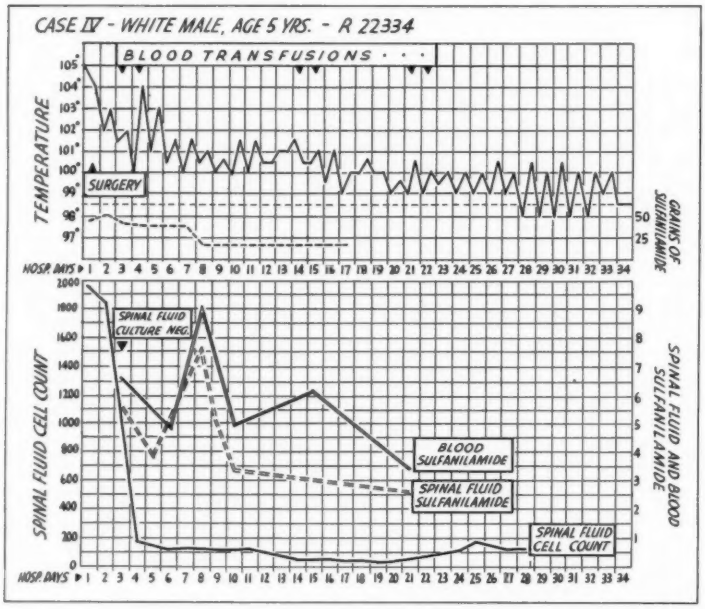


Fig. 4. Case 4. An acute unilateral hemolytic streptococcic mastoiditis with a superimposed hemolytic streptococcic meningitis.

There were positive neck, leg, and contralateral leg signs. A prompt right mastoidectomy was performed but no evidence of dural perforation was found. The lateral sinus was exposed and the wound drained and closed. Thirty-five grains of sulfanilamide was administered orally for 8 days; 45 grains 4 times, daily and then tapered off dosage during next 6 days. Eight-tenths per cent sulfanilamide solution was administered intrathecally 12 times, 3 to 4 grains each time. There were also 4 transfusions, frequent fluid drainage, and other supportive measures used. The patient had an uneventful convalescence and was discharged with healed wound and dry ear on March 25, 1938. Laboratory tests showed urinary casts and pus cells at first; white blood count 14,600 to 20,300 to normal; spinal fluid count 800; sugar too low to read; elevated globulin and protein; meningitic gold curve; 7 positive cultures and smears for Streptococcus hæmolyticus; and the right mastoid hazy on x-ray. The final diagnosis revealed (1) mastoiditis and otitis media, acute hemolytic streptococcus; (2) meningitis, hemolytic streptococcus; and (3) scarlet fever, convalescent.

Case 3. No. 22387, J. D. D., male, white, aged 12 years. This patient was an emergency admission to Riley Hospital on April 27, 1938. He had frontal headache, draining right ear, and was irrational. Two and one-half weeks before he had had tonsillitis and a week later suffered with headache and earache. Two days later a local doctor removed a bean from the right ear canal. There had been bloody and purulent drainage since. Four days after the patient showed meningitic signs and had been irrational for the 24 hours previous to admission. Examination on admittance showed a thick, purulent drainage from the right ear, and the patient was stuporous. There were positive neck and leg signs. Babinski was positive on the left, but there were absent patellar and Achilles reflexes. On the first day a simple right mastoidectomy was performed at which time pus and a tense injected dura were found. Sulfanilamide was given orally from the second day on. There were repeated spinal taps with 0.8 per cent sulfanilamide solution intrathecally 9 times, giving about 5 grains each time. Blood transfusions, intravenous fluids, anti-streptococcus serum, etc., were given but the course was steadily downward, nasal oxygen being used during the last 2 days. The patient died on May 9, 1938. No autopsy was performed but an examination of the mastoidectomy was permitted. A subluxation of stapes and a suppurative labyrinthitis were found. The laboratory findings were as follows: white blood count 18,800 to 37,800 to 31,600; hemoglobin 13 to 9.5; red blood count 4,380,000 to 3,330,000; urine contained albumin; spinal fluid count 7,600 to 9,810 to 5,600 with a high polymorphonuclear percentage; increased globulin and protein; no sugar; meningitic gold curve. Cultures and smears were positive persistently for Streptococcus hæmolyticus. Highest blood sulfanilamide

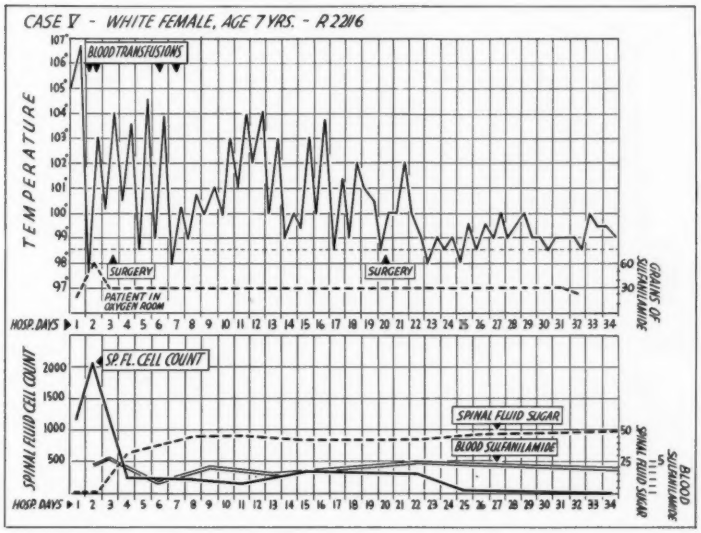


Fig. 5. Case 5. A serous meningitis accompanying an acute unilateral streptococcic otitis and mastoiditis, complicated by a petrositis of the same side and bilateral bronchopneumonia.

percentage was 8.8 milligrams. The final diagnosis revealed (1) acute mastoiditis, right Streptococcus hæmolyticus, (2) meningitis, Streptococcus hæmolyticus; and (3) right, suppurative labyrinthitis.

Case 4. No. 22334, R. D., male, white, aged 5 years. This was an emergency case brought to the Riley Hospital on April 20, 1938. The patient had a pain in neck, headache, and leg ache which developed during the 3 days previous to admission. There had been right ear drainage for 10 days, and urinary frequency was noted during the last 24 hours. Examination showed right ear draining, left drum white and bulging, patchy exudate on large tonsils, marked adenopathy on the right, and typical meningitic symptoms. A left myringotomy and right simple mastoidectomy were performed immediately. Necrotic bone, overlying the lateral sinus, and a tense and injected dura were found. The patient was started on oral sulfanilamide and given transfusions, supportive treatment, intravenous fluids, etc. Repeated lumbar punctures were done as the patient gradually improved. Two months later he required a left simple mastoidectomy. The patient received 4 x-ray treatments to mastoids and improved. He was discharged July 26, 1938. Laboratory findings were as follows: white blood count 22,500 with 82 per cent of polymorphonuclears on admission; nonprotein nitrogen 48; spinal fluid cell count 1800 with high polymorphonuclear percentage to 1,976 to normal; increased globulin and protein at first; positive cultures of spinal fluid, blood, and ear for Streptococcus hæmolyticus. The highest blood sulfanilamide percentage was 90 milligrams; blood counts became normal except for a mild secondary anemia; pus cells and casts in urine cleared. The final diagnosis revealed (1) mastoiditis, acute, right Streptococcus hæmolyticus; (2) meningitis, Streptococcus hæmolyticus, and (3) mastoiditis on the left.

Two patients with serous meningitis, resulting from an acute unilateral otitis and mastoiditis, recovered with surgery as indicated, sulfanilamide, and general supportive measures. Etiologically the otitic infection in one was due to the streptococcus, and in the other to a Gram positive bacillus.

Case 5. No. 22116, B. C., female, white, aged 7 years. The patient, an emergency case, was admitted to Riley Hospital on March 16, 1938, with headache, vomiting, fever, neck rigidity, and coma. The onset occurred 9 days previously with headache and right earache. Nausea and vomiting followed the next day and 2 days later irritability and neck rigidity were noted. Two days after the right drum drained spontaneously and irrationality and coma developed. Examination on admittance showed the patient to be acutely ill, cyanotic, comatose, with right lateral rectal weakness, bulging right drum, positive Kernig's; Babinski bilateral positive; and evidence of bilateral bronchopneumonia. The patient was placed in the oxygen room. After 2 transfusions and other supportive measures a right simple mastoidec-

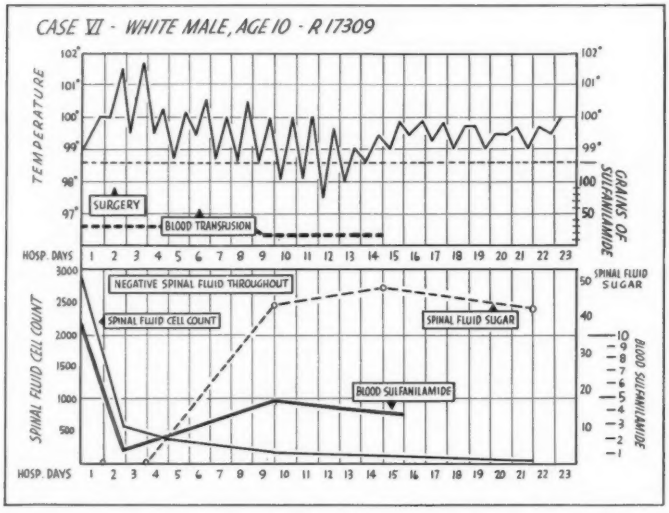


Fig. 6. Case 6. A serous meningitis with an acute unilateral mastoiditis and otitis media due to a Gram positive bacillus.

tomy was performed under local anesthesia on the third day. There was very little bony destruction and the lateral sinus and dura were not exposed. Oral sulfanilamide was given and the patient improved and was returned to the ward after 4 days. There were repeated spinal taps and 2 additional transfusions were given. However, because of redeveloping sepsis, a revision of the mastoidectomy was done on April 4, 1938. A suspected petrositis was found and the dura was exposed over the middle fossa. There was a slow but good recovery and the patient was discharged on May 15, 1938. Laboratory findings were as follows: white blood count, 18,600 to 26,200 to 7,600; hemoglobin 9 to 11; spinal fluid count 1,213 with high polymorphonuclear percentage to 2,016 to 45; sugar low, elevated globulin and protein; ear cultures were found positive for streptococcus; blood and spinal fluid cultures were negative. The final diagnosis revealed (1) otitis and mastoiditis, acute, right streptococcus; (2) serous meningitis; (3) right petrositis, and (4) bilateral bronchopneumonia.

Case 6. R. B., male, white, aged 10 years. This case was an emergency admission to Riley Hospital on February 21, 1938. The patient had headache, nausea and vomiting, pain in right ear, and stiff neck. The onset occurred 2½ weeks before with sore throat followed by earache. He improved until 1 week previous to admission when the symptoms mentioned began. His past history was essentially negative. Examination on admittance showed a bulging right drum, bilateral papilledema, positive Brudzinsky, Babinski, and Kernig. A local doctor had given the patient sulfanilamide. A right mastoidectomy had been performed at once, exposing the dura over the middle fossa; the sinus plate was soft. A good recovery followed with sulfanilamide, 30 grains being administered daily for 8 days, 20 grains daily for 6 days, blood transfusions, frequent spinal fluid drainage, and supportive measures. The patient was discharged on March 15, 1938, with the wound healed. Laboratory findings were as follows: blood sulfanilamide on admission 11 milligrams; white blood count 7,950 to 15,600 to 7,300; spinal fluid count 2,765 to 36; spinal fluid culture was negative; sugar was too low to read to normal; ear culture showed Gram positive bacillus. The final diagnosis revealed (1) acute right mastoiditis; (2) right otitis media, Gram positive bacillus; and (3) serous meningitis.

One case with acute unilateral, hemolytic streptococcic otitis and mastoiditis and an accompanying meningitis due to an unknown Gram negative bacillus was treated successfully by mastoid surgery and sulfanilamide.

Case 7. No. 21979, E. H., male, white, aged 13 years. This patient, an emergency case, was admitted to Riley Hospital on February 26, 1938, with severe right earache, fever, and weakness. The onset occurred 8 days before, but there was no aural drainage. During the year previous he had had 3 attacks of right otitis media. Examination on admission showed a bulging right ear drum, red and tender right mastoid, positive Kernig, Babinski, and Brudzinski, and temperature up to 104 degrees. On the following day a radical right mastoidectomy

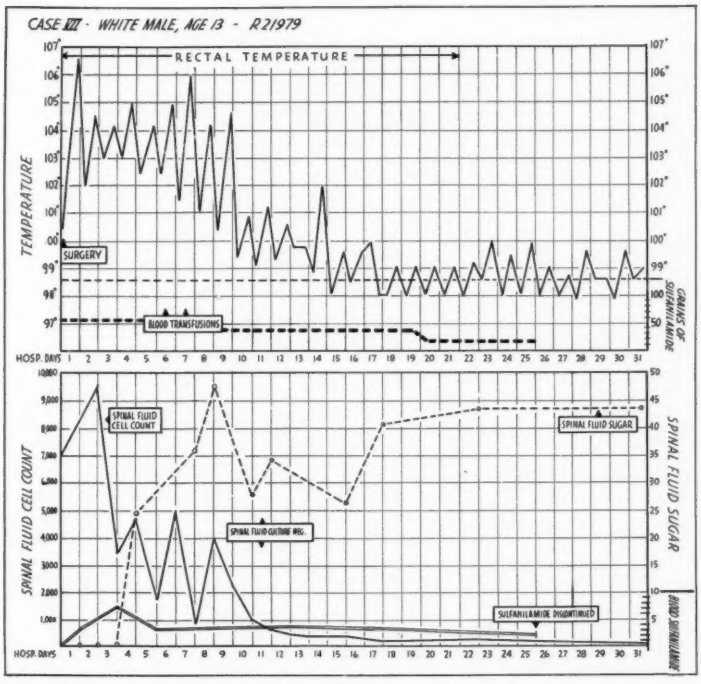


Fig. 7. Case 7. Acute unilateral hemolytic streptococcic otitis and mastoiditis, occurring with a meningitis due to an unknown Gram negative bacillus.

was performed when large cholesteatoma, extradural abscess, and massive granulations about the lateral sinus were found. The dura was widely exposed and the wound left open. The patient was given 60 grains of sulfanilamide daily for 7 days, then 40 grains daily for 12 days, and 20 grains daily for 7 days. A total of 1040 grains was given in all. Blood transfusions were given and frequent spinal fluid drainage was done. A good recovery followed and the patient was discharged April 13, 1938. Laboratory findings showed white blood count 13,000; 92 per cent polymorphonuclears; spinal fluid count 8,000; ear culture positive for Streptococcus hæmolyticus; spinal fluid cultures revealed an unknown Gram negative bacillus; highest blood sulfanilamide concentration 4.4 milligrams. The final diagnosis revealed (1) mastoiditis and otitis media, acute right Streptococcus hæmolyticus; and (2) meningitis, Gram negative bacillus.[1]

[1]According to Dr. Edith Haynes, bacteriologist of Indiana University Hospitals, this organism, "a small Gram negative bacillus obtained in culture from nine specimens of spinal fluid was non-motile. It produced acid and gas from dextrose and galactose, and slowly acidified glycerol but fermented none of fourteen other carbohydrates and alcohols tested. It did not liquefy gelatin and produced no change in milk. It formed indol and reduced nitrates to nitrites. We were unable to classify it. It is possible that it was a saprophyte."

SUMMARY

Pre-sulfanilamide records of streptococcic meningitis show a depressing mortality of almost 100 per cent, whereas recent reports and our results indicate an encouraging 20 to 45 per cent.

Approximately three-fourths of all suppurative meningitis cases are caused by a pathological auditory apparatus. The importance of this pathogenetic factor cannot be overemphasized.

The etiology and pathogenesis of streptococcic otitis meningitis are discussed briefly.

Diagnosis must be prompt. One must not delay in performing a diagnostic spinal tap, carrying through any surgical procedure that is indicated, and instituting other therapeutic measures.

Treatment of streptococcic otitic meningitis consists essentially of the following factors: (1) eradication of the etiological focus by

surgery which is adequately complete for each particular case, (2) drainage of the cerebrospinal fluid must be regular and frequent, the simpler procedures preferable, (3) support the patient conscientiously with transfusions, intravenous fluids, physical, and mental rest, etc., (4) fight the infection with serums and above all sulfanilamide.

Sulfanilamide's action may be stated as furthering bacteriostatic, bactericidal, and antitoxic action, thus reinforcing the body's own mechanisms to eradicate certain types of infection.

Neoprontosil seems to be the most promising of the many derivatives of sulfanilamide.

The application of sulfanilamide therapy as reported in the literature is unbelievably varied. No doubt, in the final analysis, such ardent widespread usage of the drug will be unwarranted.

The frequency of toxic reactions and dangerous drug idiosyncrasies in sulfanilamide therapy demands the close observation of the patient both clinically and by laboratory procedures.

The 4 cases presented of otitic hemolytic streptococcic meningitis speak for themselves as to the advisability for adequate, timely surgery and for the administration of sulfanilamide. The one fatality in this group (Case 3) unquestionably had his life prolonged even though not saved by therapy. The response in Case 2 appeared almost perfect.

We have every reason to believe that the 2 cases of serous meningitis reported here (Cases 5 and 6), judging from the severity of infection, perhaps would not have recovered had it not been for sulfanilamide.

Case 7 seems particularly interesting because of its severity and the etiological organism found on repeated spinal fluid cultures.

CONCLUSION

After reviewing the recent literature concerning otitic meningitis, particularly the type due to the streptococcus, and the chemotherapeutic drug, sulfanilamide, we presented 7 cases of otitic meningitis treated during the past year with mastoid surgery as indicated and sulfanilamide. Though the outcome of these cases was not perfectly satisfactory, we are happy to report such an unbelievable improvement in our end-results.

BIBLIOGRAPHY

1. Adair, F. L., Hasseltine, H. C., and Hac, L. R. An experimental study of behavior of sulfanilamide. J. Am. M. Ass., 1938, 111: 766–770.
2. Adolph, P. E., and Lockwood, J. S. Studies in mechanism of action of sulfanilamide; sulfanilamide in treatment of experimental streptococcic meningitis. Arch. Otol., 1938, 27: 535–551.
3. Applebaum, E. Sulfanilamide and related compounds in the treatment of meningitis secondary to ear and sinus infections. Laryngoscope, 1938, 48: 482–498.
4. Atkinson, E. M. Preoperative management of acute streptococcic mastoiditis. Arch. Otol., 1938, 28: 10–19.
5. Bannick, E. G., Brown, A. E., and Foster, F. P. Therapeutic effectiveness and toxicity of sulfanilamide. J. Am. M. Ass., 1938, 111: 770–777.
6. Berg, S., and Holtzman, M. Fatal granulocytopenia following sulfanilamide therapy. J. Am. M. Ass., 1938, 110: 370–371.
7. Bigler, J. A., Clifton, W. M., and Werner, M. Leukocytic response to sulfanilamide therapy. J. Am. M. Ass., 1938, 110: 343–349.
8. Cawthorne, T. Streptococcal meningitis. Lancet, Feb. 5, 1938, pp. 304–308.
9. Domagk, G. Chemotherapy of streptococcic infections with sulfanilamide. Deutsche med. Wchnschr., 1935, 31: 250.
10. Dwyer, J. G. Surgical indications in suppurative meningitis. Laryngoscope, 1938, 48: 461–471.
11. Eagleton, W. P. Intradural conditions in relation to rhinology and otology. Arch. Otol., 1937, 26: 534–582.
12. Finney, J. O. Severe dermatitis medicamentosa following the administration of sulfanilamide. J. Am. M. Ass., 1937, 109: 1982–1983.
13. Folsom, T. G. Case of streptococcus meningitis treated successfully with sulfanilamide. West Virginia M. J., Wheeling, 1938, 34: 33–34.
14. Friesner, I., and Rosenwasser, H. The surgical treatment of (otitic) meningitis. Laryngoscope, 1938, 48: 472–481.
15. Geiling, E. M. K., and Cannon, P. R. Pathologic effects of elixir of sulfanilamide (diethylene glycol) poisoning; final report. J. Am. M. Ass., 1938, 111: 919–926.
16. Godwin, D. E. Hemolytic strept. meningitis with recovery following use of sulfanilamide; two cases. Laryngoscope, 1938, 48: 59–64.
17. Hageman, P. O., and Blake, F. G. Clinical experience with sulfanilamide in treatment of beta-hem. strept. infections. Am. J. M. Sc., 1938, 195: 163–175.
18. Harris, T. J. Brief (historical) review of the operative treatment of purulent meningitis. Laryngoscope, 1938, 48: 458–460.
19. Harvey, A. M., and Janeway, C. A. Development of acute hemolytic anemia. J. Am. M. Ass., 1937, 109: 12–16.
20. Hemmens, E. S., and Dack, G. M. Mode of action of sulfanilamide. J. Am. M. Ass., 1938, 110: 1209–1210.
21. Hoyne, A. L., and Bailey, J. H. Use of para-aminobenzene-sulphonamide in the treatment of strept. carriers. Arch. Pediat., 1937, 54: 731–733.

23. JOHNSON, C. A. Brief review of the development, chemistry and clinical use of sulfanilamide. Illinois M. J., 1938, 73: 235–237.
24. KLINE, O. R. Meningitis of otitic origin; report of two cases. Arch. Otol., 1938, 27: 739–745.
25. KOHN, S. E. Acute hemolytic anemia during treatment with sulfanilamide. J. Am. M. Ass., 1937, 109: 1005–1006.
26. KOLMER, J. A. Sulfanilamide in the treatment of experimental streptococcic and pneumococcic meningitis. Arch. Otol., 1938, 27: 519–534.
27. LEWY, R. B. Prontosil (sulfanilamide derivative) and sulfanilamide in treatment, eight cases (five streptococcic). Ann. Otol., Rhinol. & Laryngol., 1937, 46: 1096–1111.
28. LITVAK, A. M., and KLUGHERTZ, M. B. Otogenic strept. meningitis; review of recent literature with report of recovered case. Arch. Pediat., 1937, 54: 714–725.
29. LONG, P. H., and BLISS, E. A. Para-amino-benzenesulfonamide and its derivatives. J. Am. M. Ass., 1937, 108: 32–37.
30. Ibid. Observations on mode of action of sulfanilamide. 1937, 109: 1524–1528.
31. LOVE, J. W. Non-hemolytic streptococcic meningitis; case successfully treated with sulfanilamide and prontosil. J. Lab. & Clin. Med., 1938, 23: 482–487.
32. MARSHALL, E. K., JR., CUTTING, W. C., and EMERSON, K., JR. Toxicity of sulfanilamide. J. Am. M. Ass., 1938, 110: 252–257.
33. MAXWELL, J. H. Management of the septic patient with otitis media. J. Am. M. Ass., 1938, 110: 1536–1538.
34. MOORE, R. L. Use of sulfanilamide in diseases of children. Internat. Clin., 1938, 3: 224–234.
35. MYERS, G. B. VON DER HEIDE, E. C., and BALCERSKI, M. Exfoliative dermatitis following sulfanilamide. J. Am. M. Ass., 1937, 109: 1983–1984.
36. NEAL, J. B., and APPLEBAUM, E. Meningitis therapy with sulfanilamide. Am. J. M. Sc., 1938, 195: 175–182.
37. OSGOOD, E. E., and BROWNLEE, I. E. Culture of human marrow; mode of action of sulfanilamide. J. Am. M. Ass., 1938, 110: 349–356.
38. Idem. Mode of action of sulfanilamide. J. Am. M. Ass., 1938, 110: 1770.
39. ROBERTS, E. R. Bacterial otitic meningitis. A case report. Laryngoscope, 1938, 48: 409–412.
40. SAPHIRSTEIN, H. Hepatitis and toxic erythema with desquamation due to sulfanilamide. Urol. & Cutan. Rev., 1938, 42: 101–102.
41. SCHWARTZ, W. F., GARVIN, C. F., and KOLETSKY, S. Fatal granulocytopenia from sulfanilamide. J. Am. M. Ass., 1938, 110: 368–370.
42. SILVERTHORNE, N., and BROWN, A. Treatment of meningitis due to hem. strept. with sulfanilamide. J. Pediat., 1938, 12: 504–506.
43. SMITH, A. B., and SCOTT, C. E. Streptococcal mastoiditis and meningitis following a simple tonsillectomy, with recovery. J. Laryngol. & Otol., April, 1938, 53.
44. SMITH, F. W., MAYER, K. F., AGERTY, H. A., FOWLER, R. H., and LAYTON, W. C. Anaerobic beta hemolytic strept. meningitis of otitic origin treated with sulfanilamide and culminating in complete recovery. J. Am. M. Ass., 1938, 110: 887–889.
45. TAYLOR, C. C., and CALVIN, C. V. Hemolytic strept. meningitis with recovery (treated with sulfanilamide); case. J. Connecticut M. Sc., 1938, 2: 137.
46. WEINBERG, M. H., MELLON, R. R., and SHINN, L. E. Two cases of strept. meningitis treated successfully with sulfanilamide and prontosil. J. Am. M. Ass., June 5, 1938, 108.
47. YASKIN, J. C. Differential diagnosis of bacterial meningitis of aural and of nasal origin. Arch. Otol., 1938, 27: 444–451.

LARYNGEAL TUBERCULOSIS: SURGICAL TREATMENT INCLUDING COLLAPSE THERAPY

FLETCHER D. WOODWARD, M.D., F.A.C.S., University, Virginia

THE indications for surgical treatment of laryngeal tuberculosis have undergone many changes since the comparatively recent and marked advancement of thoracic surgery as applied to pulmonary tuberculosis, and accumulated experience in regard to the treatment of the larynx itself has led to a better understanding of objectives and technique.

This study was undertaken with a view to illustrate these facts by comparing a group of 136 patients treated during the 5 year period, 1923 to 1928, with a group of 152 patients treated during the 5 year period, 1933 to 1938. Both groups[1] had local surgical treatment, chiefly galvanocauterization; but the first group had practically no collapse therapy, artificial pneumothorax alone being employed in 4.4 per cent, whereas the second group had many forms of collapse therapy applied to 49.3 per cent.

It is now a generally accepted fact that etiologically the larynx becomes involved secondary to pulmonary tuberculosis with a positive sputum, and that to obtain a negative sputum as quickly as possible is one of the main objectives in treating pulmonary tuberculosis. To this end, collapse therapy has been an important factor in improving prognosis.

Diagnosis and pathology have been well studied and presented in many excellent papers, so will not be discussed. The incidence of the complication varies widely, depending upon what stage of the disease has been studied. In our group of 288 patients with laryngeal tuberculosis out of 2,129 patients admitted to the sanatorium, 12.8 per cent had this complication on admission.

It is of interest historically to recall the statement of Sir Morrell MacKenzie in 1880, "The prognosis of laryngeal tuberculosis is always extremely unfavorable, and it is not certain that any cases ever recover." There was very little change in this view until Dr. George B. Wood, of Philadelphia, introduced treatment into this country nearly 30 years ago with the galvanocautery; and his statement, "It is undoubtedly the method par excellence for the treatment of laryngeal tuberculosis, and its use brings to the surgeon that peculiar sense of elation which he feels when, through his interference, suffering and death have been averted," marked a distinct step forward. The widespread use of the cautery, education of the public, building of sanatoria, and many other measures have contributed toward an improvement of prognosis in this condition; and now with a clearer understanding of local procedures and the development of collapse therapy we are able to offer a better prognosis in this complication than ever before. In our second group of cases, improvement was obtained in over 50 per cent of the patients; and I feel that in the very near future, with the added help of bronchoscopy in the treatment of pulmonary tuberculosis, a much higher percentage of improvement will be obtained. Dworetzky says, "The incidence of laryngeal tuberculosis is much diminished, from 25.6 per cent to 14.6 per cent in all cases of pulmonary tuberculosis, because of collapse therapy, but it is still 80 per cent in hematogenous or miliary tuberculosis."

Table I illustrates the results obtained in these 2 groups. The results show a gain of only 13.2 per cent in those obtaining a negative sputum and a gain of only 8.5 per cent in improvement at discharge, as a result of the

From the Department of Otolaryngology, University of Virginia Hospital.

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

[1] These patients were all under the care of Dr. Frank Stafford at the Blue Ridge Sanatorium, a Virginia State Tuberculosis Sanatorium. The laryngeal procedures were all carried out by Dr. Halstead S. Hedges and the writer, and the thoracic surgery by Dr. E. C. Drash of the University of Virginia Hospital. The writer is indebted to them for their collaboration in the preparation of this paper.

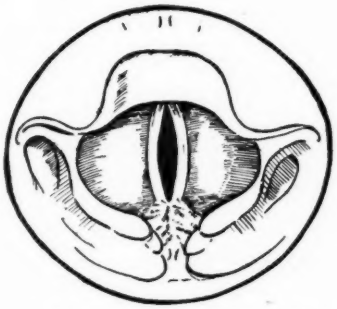


Fig. 1. A diagrammatic sketch of the larynx before operation, showing the fixation of both arytenoids in the midline by a healed tuberculous cicatrix.

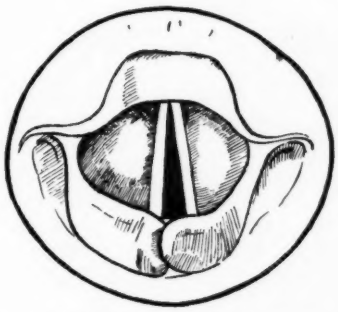


Fig. 2. A diagrammatic sketch of the larynx after operation, showing the increased airway and movable arytenoids, though some distortion is present.

addition of collapse therapy. These figures seem somewhat lower than expected because many advanced cases were treated in the second group which were not treated in the first group. All who have observed the results of collapse therapy are convinced as to its great value.

Table II illustrates the types of collapse therapy employed in the treatment of these 2 groups, and is self-explanatory. At present the trend seems to be away from operation on the phrenic nerve and toward pneumothorax, with and without pneumonolysis when indicated, and thoracoplasty.

Outside of cauterization, no other surgical procedures were necessary except 3 tracheotomies, 1 plastic operation for stenosis, and a number of bronchoscopies.

There has fortunately been a tremendous change in our ideas of medical treatment. The literature enumerates a great many drugs and other curative procedures, which have all had their advocates in the past; while now, other then anesthetic sprays for the relief of pain, the use of chaulmoogra oil as advocated by Lukens, and a few palliative remedies, no other form of medical treatment is used. Voice rest remains as one of the greatest aids in obtaining healing and should still be prescribed in all cases.

The surgical treatment has likewise undergone great change. In the past such pro-

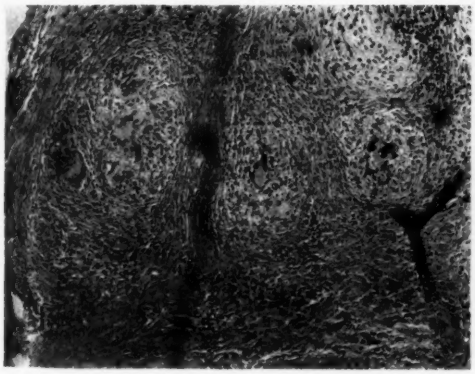


Fig. 3. Photomicrograph of the tissue removed from the posterior commissure, showing typical, well formed, conglomerate tubercles.

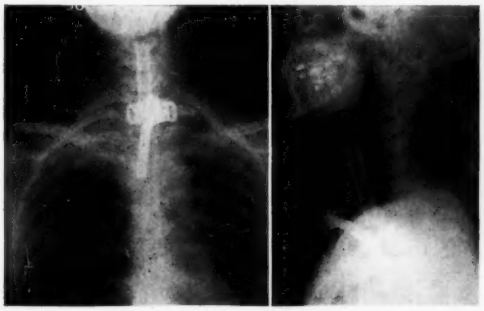


Fig. 4, left. Anteroposterior roentgenogram, showing the rubber tube in position and the subcutaneous silver wire used in transfixion to secure immobilization.

Fig. 5. Lateral roentgenogram, showing the rubber tube in position and the subcutaneous silver wire used in transfixion to secure immobilization.

TABLE I.—COMPARATIVE ANALYSIS OF 288 PATIENTS TREATED FOR LARYNGEAL TUBERCULOSIS AT BLUE RIDGE SANATORIUM

	Group I. 1923–1928	Group II. 1933–1938
Total number of patients	1090	1139
Laryngeal tuberculosis number	136	152
Laryngeal tuberculosis per cent	12.5	13.4
Sputum positive on admission—per cent	95.6	90.1
Sputum positive on discharge—per cent	63.2	50.2†
Cauterization of larynx—number	19	29
Cauterization of larynx—per cent	14.0*	19.0‡
Collapse therapy number	6	75
Collapse therapy per cent	4.4	49.3
Improved on discharge per cent	44.1	52.6§

*An additional 10.5 per cent improved with artificial pneumothorax only.
†Results show a gain of 13.2 per cent in those obtaining a negative sputum on discharge.
‡31.0 per cent improved when all types of collapse therapy were used.
§There was a gain of 8.5 per cent in improvement at discharge as the result of the addition of collapse therapy.

cedures as thyrotomy, curettage of ulcers, and even laryngectomy were advised in acute and active cases. None of these would find a sponsor today.

SURGICAL PROCEDURES

Among the surgical procedures used today, we find the following:

1. Galvanocauterization is the most valuable. The indications and technique have been well described by George B. Wood and Joseph B. Greene in various publications, and I need only add that when properly used the results are most gratifying both to the patient and to the surgeon. However, one must remember that too deep and extensive cauterization about the cords and arytenoids may produce stenosis either through inflammatory swelling or by subsequent cicatrization. The results of cauterization in suitable cases by following the sedimentation rate have been well shown by Greene.

2. The local removal by direct laryngoscopy of tuberculous tumors may be necessary at times and differs in no way from other surgical procedures done by direct laryngoscopy, except that light cauterization of the base of the tumor seems wise, in order to prevent a local spread of the disease through the traumatized tissue and lymphatics. Radiation therapy by the roentgen ray should be helpful in some cases of this nature.

TABLE II.—COLLAPSE THERAPY

	Group I Number	Group II Number
Pneumothorax		
Without pneumonolysis	6	35
With pneumonolysis	0	14
Phrenics		
Temporary	0	13
Permanent	0	9
Thoracoplasties		
Partial	0	3
Complete	0	1
Totals	6	75

3. Biopsy will be necessary in some instances in which there is a question of syphilis or carcinoma. Cases of this nature have been reported by Gabriel Tucker and others, and the writer recalls a case of advanced pulmonary tuberculosis in which biopsy showed a tuberculous ulceration and carcinoma in the same section. This patient likewise had a strongly positive Wassermann, but syphilis was apparently not involved in the laryngeal lesion. A carefully done biopsy should not be contraindicated, but light cauterization of the base would again seem to be advisable.

4. Incision and drainage of abscesses either within the larynx or subcutaneously from chondritis of the laryngeal cartilage should be carried out when necessary in the same manner as abscesses from other causes are handled.

5. The removal of the epiglottis has been done many times when disease was far advanced and painful, and has given satisfactory results, either by punch forceps with cauterization of the base, or by snare and the coagulating current.

6. A block of the internal branch of the superior laryngeal nerve has been repeatedly done for the relief of pain, but since the use of the cautery and collapse therapy, we have not found it to be necessary in a single case reported in this series. An occasional temporary block will at times be advisable, but one should never advise resection of the nerve itself.

7. Tracheotomy will be necessary for laryngeal dyspnea in rare instances, but never with the idea of putting a larynx at rest in order to promote healing, for neither objective would be obtained. The indications for tracheotomy are still those of laryngeal ob-

struction; and in tuberculosis, we find that ulceration and edema, caused either by disease or too extensive cauterization, will necessitate tracheotomy in acute cases, and for tuberculomas, cicatrization, and paralysis of both cords in chronic cases.

The technique of the operation is the same as for any tracheotomy, except that a two stage operation is preferable. As always, a tracheotomy should be anticipated and done as an elective procedure in an orderly manner under aseptic technique. It has been our custom to dissect carefully down to the trachea and expose it completely at the site for the introduction of the tube, then pack the wound open with gauze and partially close the skin. From 3 to 5 days later, the wound is re-opened, the gauze removed, and the tracheal tube inserted without difficulty. By following this procedure, the tissues are protected by granulations, and we are much less likely to get a secondary infection about the wound and skin. This method has been employed in 3 cases of laryngeal tuberculosis and in many other cases of lung suppuration without ever having an infected wound. Meyerson reported 9 tracheotomies, among which the indications were tuberculoma, necrosis of the thyroid cartilage, ulcer and infiltration of the glottis, fixation of both vocal cords by paralysis, fixation of both cords by scar tissue, and fixation by ulceration and infiltration.

8. Cicatricial stenosis of the larynx can be caused by healing of tuberculous ulcers in the interarytenoid space and surrounding region; too active cauterization in this region may also tend to a similar condition. This unfortunate condition is seen at times with an arrested pulmonary infection and often condemns the patient to a life with a tracheal tube, unless some form of plastic operation can be done in order to restore the airway. Since most of the tuberculous ulcerations are seen in this locality, it is not surprising that this problem is met at times.

In the consideration of this problem, one must be sure that the stenosis is due to cicatrization and fixation of the arytenoids and not due to paralysis of the vocal cords. In either event, a tracheotomy should be done; and if we have an arrested pulmonary lesion, a plastic repair after the method of Schmiegelow can be done; or, in the latter condition, we may gain an adequate airway after the method of Looper by the interposition of the end of the hyoid bone between the edges of the divided thyroid cartilage.

When there is scar in the posterior commissure and fixation of both arytenoids in the mid line, dilatation under direct laryngoscopy is not advisable because of the repeated trauma in a healed tuberculous lesion; but both airway and voice can be restored by thyrotomy, the careful removal of scar tissue by cup forceps, and the introduction of a rubber tube after the method advocated by Schmiegelow.

This procedure has been done repeatedly with uniformly good results for laryngeal stenosis from other causes, but because of the nature of this lesion, it has not been advocated. However, we carried it out on 1 patient with good results, and if we have an arrested pulmonary lesion and a healed cicatrix in the posterior commissure with fixation of both arytenoids in the mid line, I see no reason why it should not be applied to all similar cases.

This operation is readily carried out under local and light basal avertin anesthesia; the tube is well tolerated, and since the ends of the fixation silver wire are buried under the skin, there is very little pain. However, a feeding tube will be necessary for a few days in order to maintain sufficient nutrition, and the tracheotomy tube should be left in for several weeks until we are sure that an adequate airway has been obtained.

9. Bronchoscopy is rapidly being recognized as a valuable adjunct in the treatment of pulmonary tuberculosis, especially when there is involvement of the bronchi and trachea, also for diagnosis in questionable cases, and to furnish valuable information to the thoracic surgeon.

Kernan has reported many cases in which bronchoscopy was useful in treatment and, in summing up, says, "We have the treatment of ulcers by coagulation, silver nitrate, and the quartz rod; of strictures by stretching with copper ionization; of tubercular tumors by removal with forceps or coagulation; of ob-

struction, either by a mass of mucus or a mass of cheesy material in cavities or by a mass of cheesy material in ruptured glands, by aspiration; of secondary abscess or of bronchiectasis beyond strictures, by aspiration."

Bronchoscopy, by its value in treating pulmonary tuberculosis indirectly, may help the laryngeal lesion, and, I believe, it will occupy an increasingly important place, as time goes on, in the general treatment of tuberculosis. An interesting paper on the pathogenesis of tuberculous tracheobronchitis was presented by Bugher, Littig, and Culp.

10. Collapse therapy in some manner was carried out in approximately 50 per cent of all patients during the past 5 years. Out of a total of 1,139 admissions to the sanatorium, 568 had collapse therapy against 48 out of 1,090 patients admitted during the 5 year period 1923 to 1928. Of course, pneumothorax without pneumonolysis represents the greatest number, 331 patients having this form of collapse. With pneumonolysis the number was 82; phrenics temporary were 84; phrenics permanent, 51; thoracoplastics partial, 15, and thoracoplastics complete, 5.

Because of the many facts enumerated, we have felt that it was time to review the question of laryngeal tuberculosis and to evaluate the various surgical procedures used today in treatment, giving the results obtained in a closely controlled group of patients along with the conclusions we have reached by experience, and to point the way for future guidance; for although we may feel some degree of pride in reporting over 50 per cent improvement, as compared to Dr. MacKenzie's gloomy statement of nearly 60 years ago, we must remember that there is still a long way to go before we may allow ourselves more than a small degree of pride.

BIBLIOGRAPHY

1. Bugher, Littig, and Culp. Tuberculous tracheobronchitis, its pathogenesis. Am. J. M. Sc., 1937, 193: 515.
2. Dworetzky, J. P. Modern concepts of laryngeal tuberculosis. Ann. Otol., Rhinol. & Laryngol., 1938, 47: 481–501.
3. Greene, J. B. Prognosis in laryngeal tuberculosis. Arch. Otol., 1937, 26: 18–28.
4. Kernan, J. D. Tuberculosis of the trachea and bronchi. Ann. Otol., Rhinol. & Laryngol., 1938, 47: 306–316.
5. Looper, E. A. Use of the hyoid bone as a graft in laryngeal stenosis. Arch. Otol., 1938, 28: 106–111.
6. Lukens, R. M. Section on Medical Treatment of Laryngeal Tuberculosis. The Nose, Throat, and Ear and Their Diseases, by Jackson and Coates. Philadelphia: W. B. Saunders Co., 1929.
7. Meyerson, M. C. Tuberculosis of larynx, requiring tracheotomy. Arch. Otol., 1936, 23: 1–17.
8. Schmiegelow, E. The surgical treatment of chronic cicatricial stenosis of the larynx. J. Otol. & Laryngol., London, 1938, 53: 1–15.
9. Wood, G. B. Section on Laryngeal Tuberculosis. The Nose, Throat, and Ear, and Their Diseases, by Jackson and Coates. Philadelphia: W. B. Saunders Co., 1929.

A STUDY OF MEDICAL AND SURGICAL AIDS TO HEARING

JAMES A. BABBITT, M.D., F.A.C.S., Philadelphia, Pennsylvania

MUCH in the general field of otolaryngology has reached a certain stage in finality. The management of acute and chronic sinusitis, allergy, focal control in the Waldeyer ring, peroral endoscopy, mastoid surgery, and plastic reconstruction, would seem to have been largely accomplished; and the student, zealous for pioneer work, simply delves farther back in the embryological field or forges a little ahead with greater care and precision in already well beaten paths.

In the department of otology, however, after rather conclusive investigations in petrositis, otitic meningitis, and labyrinthine vertigo, there has occurred almost a renaissance in the medical and surgical attention to progressive deafness, a transition from the ineffective routine tubal politzerization to a combined biochemical, mechanical, and surgical attack upon this great problem. This strikes a responsive note in a large group of people, who venture the thought, "Am I growing deaf, and what am I going to do about it?"

The purpose of this paper is to group, analyze, and discuss informatively the whole problem of deafness, including its recent rather dramatic surgical episodes. Mechanical appliances, so adequately investigated by Fowler, Newhart, and the Council on Physical Therapy of the American Medical Association, need be discussed only in reference to the patient's psychological attitude. These fundamental topics are suggested for consideration: (1) medical management in deafness; (2) readjustment in upper respiratory tract from physiological and focal standpoints; (3) deafness and chronic otological infection; and (4) otosclerosis and fistulization surgery.

MEDICAL MANAGEMENT OF DEAFNESS

It is the intention to discuss deafness upon a broad basis, accepting research conclusions on acoustics, the mechanical variations in bone conduction, histological changes in the organ of Corti, etc., without sharing in the intricate research which has formed them. Deafness for the purposes of this heading refers chiefly to the popular form of progressive deafness, of the so called dry or catarrhal type, more often combining conductive and perceptive elements. One is accustomed, somewhat inaccurately, to associate conductive disturbance with the middle ear, which includes the eustachian tube, tympanic cavity, and mastoid area, and also to associate perceptive loss with the cochlea and its neural connections with the brain centers. Emerson, however, in 1924 left a lasting impression of his conception of the interrelation of these elements, in a paper under the caption, "Is Chronic Progressive Deafness a Rhinologic or Otologic Factor?"

The examination of a patient with a view to medical readjustment should be more painstaking and with a far broader scope than an ordinary routine, upper respiratory review. Accurate tests for degree and type of deafness should be carefully recorded, and the last word on familial information and the patient's environment obtained.

This basic study must include various factors in nerve damage, as suggested by Hughson, acute infections with neural influence, drug poisoning, congenital influence, nutritional, vitamin and dietary imbalance, occupational hazards, endocrinopathies, hypothyroidism and dyspituitarism, and central nervous system lues, producing cochlear degeneration by cutting off blood supply rather than affecting the auditory nerve, which is not supposedly susceptible to the Spirocheta pallida. Dean and his associates have published a convincing thesis upon allergic diseases of the ear with its special relation to labyrinthine disorder.

Preliminary work in deafness prevention has been done by a group of investigators, notably Covell in San Francisco, Dorothy Wolfe in St. Louis, Taylor in Jacksonville,

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

and Mosher in Boston, with their masterly demonstration of the prenatal influence of drugs on the neuro-otological perceptive apparatus. This fits in with the preventive and eugenic programs of child hygiene.

The psychological factor in deafness is of great medical importance. In a recent communication from Friesner, quoted by permission, occurs the following:

"If one reasons about hearing, one rapidly comes to the conclusion that hearing is an extremely complex mechanism. It is a process that is part physical, part psychical, and curiously enough is influenced by factors both physical and psychic that have no direct relationship to hearing, depend not only upon the reception of nerve stimuli aroused by vibrations in the end organ, but also upon the facile interpretation of these stimuli. Any factor that upsets the mental or physical well-being of a patient with a hearing defect disturbs hearing even though the ear mechanism is unaffected and remains as before. The psychic element in deafness is a tremendously important one. Unhappiness for a day may seriously disturb the hearing and yet on the following day the hearing may have returned to normal; obviously this cannot be accounted for by any change in the peripheral organ. Deafened patients who hear with a smile do much better than others with similar hearing defects who constantly grieve."

The nutritional index in deafened patients has claimed increased attention in recent years. Added stimulus has come from the impressive contributions upon vitamin and nutritional deficiencies so carefully presented by Selfridge in California. It will be seen what careful physiological and biochemical study of each patient must be made, including careful laboratory analysis of vitamin deficiency from A to G, phosphorus, cholesterol, and serum proteid estimation, x-ray studies of the long bones, and basal metabolism with routine blood and urine analysis.

It is but fair also to refer to the patient work of Jarvis and other nutritional groups in studying the ordinary dietary imbalance. A recent communication from him states:

"A continued study of the body process of cell oxidation has revealed that when a block in cell oxidation is present, clinical conditions appear in epiblastic tissues, of which the ear is one. Applying the theory of a block in cell oxidation, I find that children brought in by mothers with the statement, 'my child is asking over, and the school teacher tells me he does not hear well at school,' are easily straightened out. They are asked to exchange wheat foods which are difficult to oxidize for rye bread and corn meal foods. They are asked to exchange white sugar for a monosaccharide, represented by honey. They are asked to exchange milk, as a beverage, for grape juice and water, equal parts."

Cod liver oil containing organic iodine and arsenic, two good oxidizing minerals, is advised.

Crowe, with a certain dread finality, considers high tone deafness present in the fourth decade of each individual's life, and that it progresses regularly through each succeeding decade. Selfridge, however, believes that optimum nutrition can delay progress of eighth nerve degeneration when recognized early and permanently corrected; and that it is possible after the fifth decade to ameliorate deafness if the tone range from 240 to 4096 double vibrations is not hopelessly damaged. Here the remarkable result of Furstenberg's salt-free diet and ammonium chloride administration in Ménière's complex should also be mentioned.

With an enthusiastic assistant, Dr. Silcox, an analysis has been made of the results of routine nutritional and vitamin care in a series of over 100 office patients in whom the effect of vitamin B complex was carefully studied. It seems fair to assume that the changes in audiometric record as reported indicate the effects of the administration of tablets containing vitamin B 80, and vitamin G 25 Sherman units, combined with iron and administered 3 times daily over a measured period. There was almost immediate response to the initial administration with sometimes dramatic improvement. However, after varying periods of time, the hearing dropped back in some cases, suggesting that the early administration was in the nature of a neurophysiological stimulus which needed further nutritional support.

READJUSTMENT OF UPPER RESPIRATORY TRACT FROM PHYSIOLOGICAL AND FOCAL STANDPOINT

That known focal infections in the upper respiratory tract, as well as gastro-intestinal, genito-urinary, and the general lymphoid distribution, may profoundly affect both per-

ceptive and conductive integrity in the acoustic tract is indisputable. In the upper respiratory tract this concerns sinuses, teeth, the entire Waldeyer tract, pyriform fossæ, and the middle and external ear.

Ever since the expressed views of Logan Turner, Leland, Emerson, and others, confusion of opinion has persisted as to the exact contribution of lymphoid pathology to progressive deafness. The explanation of frequent disappointment in the relief of routine tonsillectomy and adenoidectomy rests in the compensatory hypertrophy of this pharyngeal tissue, poorly covered and easily re-infected from postnasal secretions sweeping down over them in acute or chronic sinus infection. Good tonsil surgery will include the removal of not only these masses but also of the small masses of lymphoid tissue at the base of the tonsillar fossa. A small triangular punch is recommended for this purpose. It is surprising how inconsequential the evidence of "punch" appears on the pharyngeal wall 48 hours afterward, and how little additional discomfort is given the patient. If these compensatory masses need only slight attention, a light coagulation diathermy while producing temporary discomfort will soon remove the trouble.

Schenck has presented a careful paper on chronic infections in the pharynx with demonstration of pathological slides in cases of articular pains, choreiform manifestations, cervical adenopathy, myalgia and nephrosis, which certainly suggest toxemic relation to our progressive deafness.

In addition to the relief of focal toxemia, there would seem to be an important field in the study of physiological readjustment in this tract. For example, the closely approximated septum and middle turbinate in the presence of marked septal deviation, in its disturbance of respiratory aeration and drainage, its possible influence in the distortion of tissue arrangement around the eustachian tube mouth, hyperplasia of turbinate structures covering sinus areas on the concave side of the nasal septum, vasomotor imbalance in the upper nasal chambers, secondary influence of hypertrophy and fibrosis upon the mucous membranes of the sinus cavities, pharyngeal wall, and even eustachian tube, are all matters of as much physiological importance as the developmental abnormalities attendant upon the high-arched palate of the mouth breather.

The tradition has grown to condemn tonsil and pharyngeal lymphoid tissue removal, as well as sinus and septal surgery in advancing deafness, with the same finality as the useless routine of tubal politzerization. The same obsession against the readjustment of the nasal septum before 16 or 17 years of age disregarded the serious consequences of nasal block in early childhood.

DEAFNESS AND OTOLOGICAL INFECTION

There are many variations under the title of otological infection which deeply concerns the function of hearing. An insidious type of infection is the almost quiescent chronicity, with intermittent drainage, in a middle ear filled with sclerotic tissue. Perhaps among the most important are sequelæ of faulty mastoid and middle ear surgery when adequate technique would have conserved hearing. Mosher, Friesner, Page, Boies, Smith, and others have rendered invaluable service in their teaching of complete surgery. This otological housecleaning in chronic infection deserves just this emphasis for both its reparative and preventive function.

Mastoid procedures by the external postauricular route have been related adequately elsewhere. Chronic middle ear suspicion in suitable cases invites the endaural approach. Preliminary steps include the careful cleansing with iodine and alcohol of the canal approach. Evidences of atresia, small, deep exostoses, eczematous crusts and granulomas must be cared for first, and, as these are chronic cases, there is no need for premature haste. Measures of option are then the complete or total ossiculectomy, some form of modified attic drainage in which free drainage from the antrum down through the posterior half of the tympanic area is secured, and the Tobey procedure of combining ossiculectomy and lateral mastoid drainage.

Lessons from the fistulization technique and from Smith's recent modification of mastoid procedure, suggest the combination of attic and antral drainage with removal of the incus or the head of the malleus in cases in which

resistant attic infection complicates that of the middle ear. This procedure, preferably by the endaural route, opens the mastoid antrum at a point two-thirds of the way down from the spine of Henle to the posterior margin of the tympanic ring. The antrum and diseased adjacent mastoid cells are carefully cleared away; the external semicircular canal and then the incus are exposed and may be removed. The conventional radical mastoidectomy does lower hearing, does not overcome all subsequent drainage, and because of granulation tissue and fibrosis, or actual labyrinthine damage, imperils the function of the internal ear. The procedure described should preserve the hearing by protecting the normal aditus, producing a flexible ossicular chain and maintaining a normal posterior tympanic wall.

The character of the tympanic perforations, central, lateral wall, and attic, must influence to a large extent the choice of procedure. The central tends toward self limitation; the lateral wall, especially in the neighborhood of the eustachian tube, permits constant reinfection; and the attic perforation, either anterior or posterior, contributes toward the walling-off of cholesteatomatous material, which in the attic-antral area produces a tumor like pressure, often with grave osseous wall disturbance. Single and multiple perforations invite ingenuity in the obtaining of coalescent and adequate drainage.

OTOSCLEROSIS AND FISTULIZATION SURGERY

This combined heading heralds the most remarkable surgery of the ear today. Far developed by Holmgren in Sweden, and Sourdille in France, the recent demonstrations of the new Lempert approach and technique have brought the problem close to able surgeons in America. The purpose of this paper is to crystallize basic facts relative to a successful fistulization. The important question at issue is the permanent maintenance of mobility in the labyrinthine fluid; in other words, the prevention of the closure of the fistula by osteogenetic change.

Historically, according to Holmgren, fistulization dates from 1876, when Kessel removed the stapes in order to replace the footplate with a movable scar membrane. Passow experienced the same results in 1897 by trephining the promontory. A group of famous otologists, including Politzer, Moure, Siebenmann, Botey and Denker, were found to be in opposition to the stapes extraction.

Barany in 1910 opened a fistula in the posterior vertical canal. In 1913 Jenkins opened the horizontal semicircular canal twice, covering one with a Thiersch and another with a metal flap, but returning deafness discouraged him. Holmgren began using magnifying glasses in 1920, making a fistula in the promontory, but this, too, closed. In 1922 he had better success with a mucoperiosteal flap from the ampulla. At the time of his report in 1937, he had done about 34 human cases in 15 years, and of late was using gold leaf prosthesis, covered with fat. Upon the principle of decompression of the labyrinth, he made fistulas to horizontal and posterior semicircular canals and sometimes even to the anterior vertical. Immediately following operation, some vertigo appeared which disappeared within a month. Tinnitus disappeared during the operation, but in failure of maintenance of hearing, timed its own return with that of healing in the general operative field.

Sourdille, in 1937, presented his new fistulization technique for the surgical treatment of otosclerosis. In his discussion he first mentions 2 other schools of surgical attention: (1) the Wittmaack-Heyninz-Rollin method, designed to combat the perilabyrinthine venous stasis; he suggests calling it the "elevation of the supra-tympani dura mater"; (2) the Alonso-Chiarino method of removing one parathyroid or suppressing its function by ligation of its principal vessels.

The operation of Sourdille was originally in 3 stages and by postauricular incision. The first 2 stages were devoted to mastoid exenteration, exposure of the external semicircular canal and preparation of a reconstructed tympanic system. His operation, termed "tympano-labyrinthopexy," consisted in joining the covering membranes of the labyrinthine fistula with the superior border of the tympanic membrane whose excursions have been increased by the removal of the

malleus head. The incus is preserved in its place, and, according to Holmgren, acts as a mobile prop and permits displacement of the whole system. Sourdille's operation, according to his report, has been performed on 109 patients, with 10 times or more previous hearing distance in 40 per cent, 5 to 10 times previous hearing distance in 14 per cent, mediocre results of 2 to 5 times previous hearing distance in 20 per cent and no fatalities—in other words, 54 per cent of definite improvement.

Lempert of New York has developed the one stage procedure via the endaural approach, and in July, 1938, reported operations on 23 patients, 4 of whom had a bad background. Nineteen showed good practical improvement, but the canal remained open in 22 of the 23 cases. Since this report, he has added 36 fistulization operations, making a total of 59. In all but 9 of these cases the fistulas have remained open. In a recent visit to New York to observe his technique, we personally reviewed 20 of these cases. Of these 20 operated-upon patients, after a varying period of from 3 weeks to 9 months, all had well healed flaps and 19 of the 20 a good fistula reaction. The one weak test followed an otitis media complication. Of course these were favorable cases, selected for our review. All the patients appeared optimistic and some showed the exhilaration euphoria to which ear patients are prone. At the time of our review there was insufficient time to test the improvement of each patient with the audiometer, but there were unquestionably results sufficiently favorable, to be a source of great stimulation for future work.

An estimated analysis of endaural fistulization in this country, by other operators than Lempert, gives a total of 30 cases, 8 of which thus far give promise of favorable results; 6 apparently had labyrinthine complications, and the remainder showed doubtful gain over the pre-operative status, but there were no fatalities.

While somewhat difficult to place chronologically, mention must be made of a patient reported in 1935 by J. S. Fraser of Edinburgh, upon whom he had done a radical mastoid and fistulization 17 years previously. The bony cap of the lateral canal was removed and a graft applied with a favorable hearing result and a positive fistula test after 17 years.

These results have been presented to indicate that from a surgical standpoint this operation reasonably points to success. While somewhat tedious, two facts are definite, as stated by Canfield in his discussion at the American Otological Society's meeting; first, that the fistula increases the air-borne sound; and second, that human beings do not incur undue surgical risk and are only moderately inconvenienced by the operation.

The operation presents to an observer about 5 important steps: one, the exposure through a mastoidectomy of the horizontal semicircular canal; two, the skeletonizing of the anterior and posterior epitympanic areas for liberating the tympanic sulcus; three, the isolation and removal of the malleus head; four, the careful burring into the semicircular canal, a saucer or trough-like excavation, to relieve the endosteal retention without injuring the membranous canal; and five, the application of a careful flap, constructed from fibrous scar tissue, mucoperiosteum, tympanomeatal or Shrapnell's membrane, to close the fistula adequately. The cases selected should be definitely otosclerotic cases or combined progressive deafness closely simulating them, without mastoid or posttympanic infection.

Otosclerosis, according to Cahill, clinically presents an ankylosis of the stapes, progressive deafness usually bilateral, and a severe tinnitus, yet with normal drum membranes and patent eustachian tubes. It must satisfy the Bezold triad of lengthened bone conduction, a negative Rinne test, and elevation of the lower tone limits; and there should probably accompany it the paracusis of Willis, meaning the ability to hear conversation better in the presence of a noise, and the pinkish tinge over the promontory representing the active, underlying osteoporosis. Its etiology is variously assigned to familial transmission, toxemia, infection, adolescence, or the pregnancy complex.

It is appropriate to present the endaural work of Hughson in closure of the round window for the aid of hearing in progressive deafness. His work has always been so careful

and scientific that it deserves most thoughtful consideration. In his opinion, "the demonstrated extent of nerve involvement and its probable cause are alone the standards whereby operability can be determined. Routine loudness balances, repeated bone conduction audiograms with appropriate masking, supplemented by fatigue tests, give accurate information as to the amount of the organ of Corti and nerve remaining." When this has been established, he feels that fixation of the round window by graft increases the intensity of tone stimulus. He has presented the results of 25 operations for blocking the round window niche with a tissue graft. No further impairment occurred in any and a maximum of 20 per cent improvement was obtained in 1 patient, with an average increase of 10 decibels in all critical frequencies. This improvement occurs later than in the fistulization procedure. Wishart, in his admirable discussion, has commended Dr. Hughson's painstaking and accurate work but questions the ultimate fate and value of the graft.

In conclusion we have tried to give parallel incidents in the nutritional, the upper respiratory, elimination of infection, fistulization, and round window graft aids to hearing. There is apparently not too wide a difference in the measured results of each, though there is a wide variance in the dramatic finesse involved. It may be that composite decision will prefer ultimately to accept the value of the greatly improved mechanical devices and educate the sensitive deaf to accept a hearing apparatus as they would a toupee or false teeth. Nevertheless, it is hoped that this discussion will increase in the surgeon *faith* in vitamin and nutritional possibilities, *hope* for the slowly demonstrated improvement in upper respiratory correction, and *charity* toward the pitfalls and by-passes of labyrinthine fistulization.

REFERENCES

1. Cahill, H. P. Otosclerosis. The Nose, Throat and Ear and Their Diseases. Jackson and Coates, Philadelphia: W. B. Saunders Co., 1929, p. 503.
2. Covell, W. P. A cytologic study of the effects of drugs on the cochlea. Arch. Otol., 1936, 23: 633.
3. Dean, L. W., Agar, J. S., and Linton, L. D. Allergic diseases of the ear. Laryngoscope, 1937, 47: 707.
4. Dickie, J. K. M. Chronic progressive deafness, etc. Arch. Otol., 1936, 23: 694.
5. Editorial. Vitamin C and complement. J. Am. M. Ass., June 25, 1937, 110: 2157.
6. Emerson, F. P. Is chronic progressive deafness a rhinologic or otologic factor? Ann. Otol., Rhinol. & Laryngol., 1924, 33: 865.
7. Fowler, E. P. Report of The American Otological Society Representatives on Committee for Hearing Aids and Audiometers of Council on Physical Therapy of Am. M. Ass. Laryngoscope, July 1938, 47.
8. Idem. The factual background for the treatment of progressive deafness from otosclerosis. Laryngoscope, 1937, 47: 847.
9. Fraser, J. S. Bilateral otosclerosis. Radical mastoid operation on worse hearing ear, etc. J. Laryngol. & Otol., 1935, 50: 700.
10. Friesner, I., and Druss, J. G. Critique of the present treatment of deafness due to lesions in the conduction mechanism. Arch. Otol., 1937, 26: 259.
11. Holmgren, G. The surgery of otosclerosis. Ann. Otol., Rhinol. & Laryngol., 1937, 46: 312.
12. Hughson, W. The inner ear from an experimental and clinical standpoint. Ann. Otol. Rhinol. & Laryngol., 1938, 47: 68.
13. Idem. Rationale, technique, etc., with grafts in the round window. Laryngoscope, 1938, 48: 533.
14. Mosher, H. P. Does animal experimentation show similar changes in the ear of mother and fetus after ingestion of quinine by the mother? Laryngoscope, 1938, 48: 361.
15. Lempert, J. Improvement of hearing in cases of otosclerosis. Arch. Otol., 1938, 28: 42.
16. Newhart, H., and Hartig, H. E. Performance characteristics of electrical hearing aids for the deaf. Arch. Otol., 1936, 23: 617.
17. Perkins, O. C. Dietary deficiencies as the etiological factor in certain neurological syndromes. J. Nerv. & Ment. Dis., 1936, 83: 505.
18. Schenck, H. P. Chronic infections in the pharynx. Tr. Am. Laryngol. Ass., 1936, p. 164.
19. Selfridge, Grant. Chronic progressive deafness from a nutritional standpoint. A preliminary report. Ann. Otol., Rhinol. & Laryngol., 1937, 46: 875.
20. Idem. Can certain diseases of ear, nose and throat, especially degeneration of eighth nerve, be classified as deficiency diseases? Laryngoscope, 1936, 46: 85.
21. Idem. Eighth nerve high tone deafness from a nutritional standpoint. Ann. Otol., Rhinol. & Laryngol., 1937, 46: 93.
22. Shambaugh, G. E., Jr. Chronic progressive deafness, including otosclerosis and diseases of the inner ear. Arch. Otol., 1937, 26: 583.
23. Smith, J. Morrisset. Surgical technique for the conservation of the hearing in chronic mastoiditis. Laryngoscope, July 1938.
24. Sourdille, M. New technique in surgical treatment of severe and progressive deafness from otosclerosis. Laryngoscope, 1937, 47: 853–873.
25. Idem. Present position of surgical treatment of otosclerosis. J. Laryngol. & Otol., 1938, 78–83.
26. Taylor, H. M. Deafness from drugs and chemical poisons. Laryngoscope, 1937, 47: 692.
27. Walker, H. Surgery of the nasopharynx in chronic progressive deafness. Laryngoscope, 1938, 48: 552.

THE PHYLOGENETIC DEVELOPMENT OF THE EAR

J. M. ROBB, M.D., F.A.C.S., F.R.C.S.E., and HAYDEN PALMER, D.M.D., Detroit, Michigan

KNOWLEDGE of the phylogeny of the human ear involves a study of the organs of hearing of nearly related contemporary species as well as of species as remote in relationship as their occurrence in time.

The fact that in many insects there are highly specialized organs for the production of sounds indicates that insects possess also the function of hearing. The sound-producing organs of grasshoppers and crickets probably produced the first not merely accidental and functionless sound in the history of life. It serves principally to bring the sexes together. The sound is produced by the friction of a file on the under side of the left forewing over a ridge on the upper side of the right.

Auditory organs in their simplest form consist of fine rods suspended between two points of the integument and connected with nerve fibers. This morphological unit may or may not be associated with a tympanum. The peg-like rod, with nerve attached, is known as the scolopophore. The wall of the scolopophore is composed at either end of 7 ribs, each of which is divided in the central portion, making 14 ribs. The entire scolopophore is bathed in fluid and is free to vibrate.

In other species, more elaborate organs are developed. In grasshoppers, highly specialized ears are situated, one on each side of the first abdominal segment. The tympanum is conspicuous as a thinned portion of the body wall. Closely applied to the inner surface of each tympanum is a ganglion known as Muller's organ. Intimately associated with Muller's organ are two horny processes (bone conduction) and a pear-shaped vesicle. Near the margin of the tympanum there is a spiracle, or the Eustachian analogue, which admits air to a space inside the tympanum, or the tympanic chamber. As the nerve endings in Muller's organ are attached to the tympanum, it is classed as a chordontal organ of the integumental type. The other type of chordontal organ ends free in the body cavity.

In the long-horned grasshoppers, known as locusts or katydids, and in the crickets there is a pair of tympana near the proximal end of the tibia of each foreleg. Some forms present an external canal. Within the legs bearing these tympana there are chordontal organs. There is also a trachea in each leg of a locust. The tracheas in the forelegs are remarkable for their great size and for the division into two branches. These two branches reunite beyond the end of the chordontal organs.

There are really 3 distinct types of chordontal organs, or cochleæ, in each foreleg of the locust. In the supratympanal form there is a ganglion composed of nerve endings which are scolopophores of the integumental type. Immediately below this is the intermediate organ in which the scolopophores are of the subintegumental type. Third, there is Siebold's organ, or crista acoustica, on the outer surface of the large trachea. This consists of a series of scolopophores which diminish in length toward the distal end of the organ. It forms a ridge on the trachea, therefore the name, "crista acoustica."

The hearing mechanism of the mosquito is connected with the antennas. At the bottom of the antennas is an enlargement, the scape, in which the muscles lie. Just above the scape is a greater enlargement, the pedicle holding Johnston's organ or the auditory apparatus, which differs in the two sexes, being more highly specialized in the male. Briefly, this organ consists of whorls of scolopophores, with their attached nerves. Experimentally it has been shown that the different whorls, which decrease in length on successive segments, are caused to vibrate by different notes (Mayer, 1874). It was formerly believed that the great specialization of Johnston's organ in male mosquitoes enabled the males to hear the songs of the females. But it has been

From the Departments of Ear, Nose, and Throat of Harper and Herman Kiefer Hospitals.

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

found that in some species, at least, the females seek the males. Rudyard Kipling may not have had this in mind. The fact remains, however, that the distinctive feature is the presence of scolopophores, which is characteristic of the auditory organs of other insects. The grasshopper has its hearing mechanism in the abdomen; the cricket, in the foreleg; the mosquito, in the antennas. Apparently, nature has cared very little where she put this organ so long as it functions.

When, and in what form, did this function of hearing first appear? Who was the first listener? If a fish is sensitive to vibrations of similar frequency in the water, is that analogous to hearing vibrations in the air? And, if so, is the sensitiveness of an earthworm to vibrations in the surrounding soil similar—and the earthworm has a head brain—or must we classify it as a different sense? The sense of hearing and the sense of touch are closely allied, and it is hard to draw the line between them and to differentiate which shall be called hearing and which not. In certain insects, however, a real sense of hearing exists which is in some way comparable to our own. In fact, there is a striking similarity of mechanism manifest in the parallel development of the invertebrate and vertebrate lines.

The earliest ear structures are associated with the static and kinetic labyrinth. The invertebrate crayfish, a glorified worm and descendant of the trilobite, has a statolith, and it most probably appeared upon the scene earlier than the vertebrate lamphrey and hagfishes with their untricle and saccule. The sacculus becomes progressively differentiated into the lagena and eventually into the cochlea. The utriculus and semicircular canals show far less change. With the substitution of air for water the invertebrates develop a more delicate mechanism, as demonstrated in the scolopophore. Inasmuch as scolopophores are found in the worm or embryonic stage of some flies it would seem to predicate the presence of hearing elements in very early extinct forms. The premise of this conclusion rests in the fact that the embryo in its development repeats the history of the race and so in this instance it would carry the function of hearing back to an aboriginal wingless stock.

Let us view in retrospect in order to make a reckoning in geological time. For instance, consider the Archaeozoic or pre-Cambrian period, 1,850,000,000 years ago, according to Schuckert and Dunbar, when the bigerminal forms were just getting under way, or just a little later, perhaps when the mid-Cambrian trilobite was flourishing 650,000,000 years ago. Some forms of these Crustacea have remained unchanged generically over the same span of time and swarm in the oceans today, illustrating the principle of balance or stability of type. While fossil forms would indicate that the harlequin fly developed this side of the Carboniferous period, 300,000,000 years ago, still the presence of scolopophores in this fly's larvas might, as mentioned, point to the occurrence of the same in an early form and at an early date. And so, it seems reasonable for us in this political time and in the current parlance to choose the initials P.E.Z. (Paleozoic) and push back the first listener a few odd hundred million years.

The central line of fish evolution, destined to give rise to all the higher and modern fish types, is found in the typical cartilaginous skeleton, jaws and four fins of the primordial sharks of Upper Silurian time, 500,000,000 years ago. The question, "Does a fish hear?", would seem to be answered with the presence of a primitive lagena. While both the shark and the carp family have primitive lagenas, the shark has microscopically more elements.

In the brains of the animal, from fish to man, the cochlea is associated with a center in the mid-brain. The conditioned reflex for hearing in fish was established by H. A. Bull and reported in 1930. And we have the familiar example of driving herring into nets with the beating of pans.

We have the seeming paradox of fish with ear bones or ossicles. The system of bones is analogous to that found in higher vertebrates but it connects with the lungs or air-bladder and not with the tympanum. For that reason, the ossicular chain is limited to the group of lungfish, or to the teleosts with an equivalent of the lung which is the swim bladder. The arrangement for this purpose is especially elaborate in the carp or catfish families. Weber, in 1820, described a series of paired

ossicles which he erroneously called stapes, malleus and incus, which, as shown in the carp, connect a part of the inner ear, the atrium sinus impar with the swim-bladder. It is also of interest that the tubular sinus impar, aside from connecting the ossicles with the lagena, also directly connects the two labyrinths. The entire apparatus would then function as an organ of hearing. Weber's views remained practically uncontested for half a century, but recently much has been written both for and against this theory. The bones are not homologous with those of the ear of higher mammals, however, being processes of the anterior vertebras. Those of higher mammals develop from the multiple jaw bones, as seen in the crocodile or alligator.

The sharks and the lung fish (squalus acanthus) are alike in this respect; there is a small canal extending from the labyrinth to the surface of the skull. However, the shark has no lungs or swim bladder and, therefore, no weberian ossicles. The air bladder or swim bladder is closed as an organ of respiration, although it has taken on collateral functions. It picks up vibrations as through bone conduction, transmitting them to the ossicles. It also acts as a hydrostatic organ of equilibrium by aiding in the decompression of air from the vascular content in coming from the deep. In other words, it serves as the decompressor chamber of the caisson worker. It is said that when some of these fish are brought from a depth in a certain European lake the swim bladder becomes so large the fish cannot navigate. However, after being stuck with a pin, they swim in the shoal water perfectly.

Finally, Moreau has drawn attention to the Trigla (red mullet), a fish having an air bladder supplied with muscles which serve to make the air bladder produce a sound. So you see, we finally have the fish in the position where he is talking. What does he say?

Certainly through all phylogenetic progress the cosmic processes cease to run down and begin to build up, abandoning old forms and constructing new ones. In like manner, in the amphibian and reptile, the lower jaw produces the analogue of the ossicles in man. Below mammals, an entirely different type of middle ear anatomy is found. The reptiles show a complex evolution in which the half dozen or so bones of the lower jaw are lost one by one; the three bones closest to the jaw articulation leave the lower jaw and become associated with the skull. The ear structures which, in reptiles, are outside of the skull, in mammals, become enclosed in it. The lower jaw articulates in the alligator by means of an extra bone (the quadrate) as well as with an articular cartilage. In some forms of reptiles, as for example the Anomodontia, the articular bone articulates not only with the quadrate but also, to a large extent, with the squamosa, the quadrate shrinking in size and developing processes which give to it very much the appearance of either the incus or the malleus of the mammalian ear. As a matter of fact, it fits in with a fair interpretation of the parts of embryology. The stapes is the equivalent of the columella in the reptile; the articulare is represented by the malleus, and the quadrate, by the incus. The skull of the mammal differs from that of the lower vertebrates in that it is a more consolidated whole. The numerous parts from which the mammalian jaw ossifies is reminiscent of the former state.

The sense of hearing in reptiles is apparently not very acute, although tortoises and turtles are frightened by noise and can distinguish sounds. If it were not so, they would have no voice, which is very tiny and piping in most tortoises during the pairing season. In most water tortoises the tympanic membrane is thin and quite exposed. Lastly, in Chelone, the tympanic cavity is filled with a plug of the much thickened skin, possibly an adaptation to the water pressure when these creatures dive to considerable depths. In the crocodile, the outer ear lies in a recess and this carries a flap of skin provided with muscles to close the ear tightly. The tympanic membrane is visible at the bottom of the recess and, shining through it, is part of that cartilage which is homologous with the malleus of the ossicular chain. Diverticula from the middle ear penetrate the bones of the rear of the skull and form pneumatic spaces in these heavier regions of the skull. The ear is likewise peculiar in snakes. There is a long columellar rod with a fibrous or cartilaginous pad at the outer end which plays against the

middle of the shaft of the quadrate, an arrangement, which we must assume, produces a thundering noise in the inner ear, since every motion of the quadrate during the act of swallowing conveys the vibration directly to the fenestra ovalis. The tympanic cavity, eustachian tubes, and tympanum are abolished and no external traces of the ear are visible.

The croaking of male frog-like amphibia is almost certainly life's first vocal music. The frogs have simple middle ear expansions containing air and apparently there are no diverticula from the main cavity.

According to Henry Fairfield Osborn, founder and former president of the American Museum of Natural History, the dinosaur had a mastoid. In the field of paleopathology, the dinosaurs, considered extinct reptiles of the Triassic period, 150,000,000 years ago, showed evidence of arthritis deformans. It is a matter of reasonable conjecture that the earliest evidence of inflammatory change in bone or mastoiditis might be found, therefore, in this fauna. Why did the dinosaur have a mastoid? The next appearance of a pneumatized mastoid process is found in the anthropoid apes, a development of about 65,000,000 years. Where was the invisible evolution of the hereditary germ carried those 85,000,000 years? Or should this interval be considered as that of the "Dark Ages" of the mastoid?

The birds resemble the reptiles among other things in having no ear trumpet or pinna. Their sense of hearing is acute but it has been observed that many kinds of birds are indifferent even to loud noises. Attention is most readily given to sounds which stimulate interest in an inborn equipment or an acquired association. The parental danger note stimulates the crouching instinct of the young partridge. The semi-circular canals of the ear show some correlation with the perfection of flight. They are better developed in a swallow than in a swimming bird.

In some forms of the owl, the external canal reaches nearly the whole height of the skull, being directed upward and downward. In Nyctala, this asymmetry extends to the bones of the skull itself. The large ear is apparently correlated with a keen sense of hearing in some cases but not in all. It has been suggested that the development of the mastoid may be secondary to the pull of muscular attachments. But, consider the owl, his eyes are practically fixed and to change his line of vision he has to move his head which he accomplishes in an arc of 270 degrees. Should he not have the mastoid?

As a proof, among others, that the whale is the progeny of terrestrial creatures, are occasional traces of external ears. The bones related to the organ of hearing, the tympanics, and petrous bones, are very solid and dense in structure. Moreover, they are but loosely attached to surrounding bones and are thus easily and frequently lost. In whalebone whales the external canal is blocked by a large mass of wax several inches in length which would greatly interfere with hearing. It is believed that vibrations in the water reach the ear by sacs, given off by the eustachian tubes or by bone conduction. In the seals, the external ear has vanished. In the sea lion, the external ear, though small, is persistent. The ossicles differ from those of their terrestrial allies in their large size and massive growth. In this they have come to be like those of the whales.

Bats are on the lookout, of course, for the sounds of insects and require an acute ear, but the fact that their flight is directed by a "sound beam," the echo of the sound they emit, their hearing must be most acute to use these reverberations at the speed they fly.

It cannot be doubted that the increased complexity of the brain of mammals raised them in the scale, as does also the delicately adjusted series of bonelets in the middle ear. In connection with the elaboration of the chain of auditory ossicles, it is very usual for mammals to possess a thin inflated bone, sometimes partly or entirely formed out of the tympanic bone, the tympanic bulla.

The tympanic bulla of dogs is often very much inflated; if flatter, as in bears, it is still large and conspicuous. In the bear-like carnivora a fairly typical arctoid bulla is seen, but, as a group, the bulla flattens off toward the bony meatus; in the raccoon, the bulla is much smaller; in the polecat, it is fairly swollen but there is a little flattening toward the meatus. In cats, there is a double cavity

in the bulla almost separated by a septum; in the pig, it is divided by many septa into a cancellous structure.

It is convenient to mention, here, a curious fact that white cats with blue eyes are said to be always deaf. Should the mother produce a litter of kittens and any one of them has a single speck of color on its fur, it invariably possesses the usual faculty of hearing, but, if perfectly white, it is invariably deaf.

All the lemurs of Madagascar differ from the African forms in that the tympanic ring is completely enclosed by the bulla ossea, but without osseous connection with the same.

Valsalva, in the seventeenth century, observed that those animals having no mastoid cells have large tympanic cavities or bullas. Phylogenetically, the mastoid cells are not found in animals below the level of the apes. There is a considerable pneumatization present in the chimpanzee and the gorilla. The chimpanzee has no antrum, while the gibbon and the orang have no mastoid process. In the common rhesus monkey the petrous bone is cancellous with cavities connected by many small openings into the tympanic cavity. The arrangement obviously differs from that of the higher apes and man. Various groups of mammals have diverticula from the middle ear into the petrous, squamous bone, or zygomatic arch. Some of the marsupials have actual continuities from one middle ear to the other by means of cancellous tissue, and apparently the sphenoid can be so traversed.

Finally, and briefly, there are 3 groups with diverticula from the middle ear; namely, (1) certain reptiles and birds in which the diverticula are not surrounded by bone; (2) mammals in which the simple diverticula are surrounded by bone; and (3) the great apes in which there are diverticula in cancellous bone. In the human and gorilla there can be no doubt about the terminology, mastoid cells.

Something of the phylogenetic development of the mastoid process as it immediately applies to man, more particularly in his primitive state, is included here.

The recent discovery, November, 1936, of three remains of Peking man has afforded the opportunity of showing here the rudimentary mastoid process of our most ape-like relative, who lived 600,000 years ago. The elongated low brain case and large supra-orbital ridges show relationship to the apes. Ability to make fire and to use tools, together with the capacity of the brain case, proves the Peking man to have been a human. The mastoid process, shown in relation to the external osseous canal, appears to be more rudimentary and more like that of the ape than that of any known man. It is shown in comparison with the skull of the Peking man, the chimpanzee, the Neanderthal man, and a North China modern.

Later computations on the age of the Neanderthal skull places it at about 200,000 years. It is apparently better developed than the Mongoloid or Peking man of 650,000 years. Pithecanthropus is probably about the same period as the Peking man, or perhaps a little older, but the lower temporal regions are missing. Sir Arthur Keith's projection of this area looks just about like the skull of the Peking man.

In skulls of the modern type, a pyramid-shaped process of bone, the mastoid process, descends immediately behind the ear. To this process certain muscles of the neck, concerned in moving the head, are attached. It is only slightly developed at birth, attaining its full size when the individual has reached adult life. In the gorilla, a mastoid process is present, but, instead of growing downward to form a pyramidal process, it expands into a flange-like plate, forming part of the bony occipital platform on which the muscles of the neck are implanted. The pit or fossa from which the digastric muscle arises is thus left exposed on the anthropoid skull below the mastoid process. In skulls of the modern type, the pyramidal process covers and hides the digastric fossa. In the Neanderthal skulls, the mastoid process does not assume a distinct pyramidal form. In its shape and relations, it is intermediate to the form seen in young anthropoids and to that in men of the modern type. It will thus be seen that in the mastoid region even the Neanderthal skulls show a series of characters which may justly be regarded as simian in nature and origin.

The function of the mastoid portion of the temporal bone has not been clearly determined. The mastoid is not even vestigial as

the vermiform appendix or some other structures, the removal of which has not shortened life or impaired physiological processes. Nature apparently abhors too much cortical bone, preferring a trestle work of cancellous structure, paranasal sinuses and, may I add, the cellular structure of the mastoid.

BIBLIOGRAPHY

1. Beddard, F. E. Cambridge Natural History. Vol. 10, p. 206. London: MacMillan & Co., Ltd., 1904.
2. Bridge, T. W. Cambridge Natural History. Vol. 7, p. 297. London: MacMillan & Co., Ltd., 1904.
3. Bull, H. O. Science Progr., 1930, 25: 97.
4. Comstock, J. H. An Introduction to Entomology. P. 145. Ithaca, N. Y.: Comstock Publishing Co., 1936.
5. De Chardin, T. Our most ape-like relative. Natural History, 1937, 40: 514.
6. Evans, A. H. Cambridge Natural History. Vol. 9, p. 399. London: MacMillan & Co., Ltd., 1904.
7. Evans, H. M. The origins of hearing. J. Laryngol., 1935, 50: 649.
8. Gray, A. A. The Labyrinths of Animals. Vol. 1. London: J. and A. Churchill, 1907.
9. Gadow, Hans. Cambridge Natural History. Vol. 8, p. 445. London: MacMillan & Co., Ltd., 1904.
10. Hartman, C. G., and Straus, W. L., Jr. The Anatomy of the Rhesus Monkey. P. 347. Baltimore: The Williams & Wilkins Co., 1933.
11. Hatt, Robert. Personal communication.
12. Jordan, D. S. A Guide to the Study of Fishes. Vol. 1, p. 119. New York: Henry Holt & Co., 1905.
13. Keith, Arthur. The Antiquity of Man. Vol. 2, p. 732. London: Williams & Norgate, Ltd., 1929.
14. Osborn, H. F. The Origin and Evolution of Life. P. 121. New York: Charles Scribner's Sons, 1930.
15. Idem. The Age of Mammals. P. 82. New York: The MacMillan Co., 1921.
16. Retzius, Gustaf. Das Gehor Organ der Wirbelthiere. Stockholm, 1884.
17. Stetter, H. Untersuchungen ueber den Gehorsinn der Fische. Ztschr. f. vergl. Physiol., 1929, 9: Nos. 2 and 3.
18. Thomson, J. A., and Geddes, P. Life, P. 255. New York and London: Harper & Bros., 1931.
19. Weidenreich, Franz. The James Arthur Lecture. American Museum of Natural History, 1938.

OCULAR MANIFESTATIONS OF ALLERGY

W. BYRON BLACK, M.D., F.A.C.S., Kansas City, Missouri

CLOSE observance by practitioners during the early Christian era proved that food for one man was poison for another. In 1796 Edward Jenner vaccinated for smallpox successfully; Magendie produced anaphylaxis by injections of egg white in rabbits; Pasteur used bacterial inoculation; and Flexner's work on anaphylaxis appeared during the latter part of the nineteenth century. A great amount of forward, constructive work has been done by many brilliant men, too numerous to mention. The foreword written by Woods, to *Allergy and Immunity in Ophthalmology*, by Dr. Wilmer, gives a beautiful description of the history of allergy.

Following the epoch-making discoveries of the phenomena of anaphylaxis, numerous investigations were conducted to determine the relationship of the processes of hypersensitivity to diseases of the eye. These and other experiments have indicated that the tissues of the eye, like most tissues, take part in the immunological reactions of allergy with the production of antibodies or of cellular reactions not unlike allergic processes elsewhere. They suggested that allergic reactions may be responsible for certain ocular conditions which were attributed formerly to some other cause. Thus, until recently, the only allergic condition which concerned the ophthalmologist was the conjunctivitis accompanying hay fever, since this necessitated differentiation from other types. Recent reports of the possible allergic character of vernal conjunctivitis, and of so called "allergic cataract," as well as the relationship of bacterial allergy to certain inflammatory conditions of the eye, have stimulated study of the possible relationship of allergy to these ocular abnormalities.

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

ETIOLOGY

A disturbance of the endocrine glands has been cited as the cause of every disease of obscure etiology. Spring catarrh is no exception to the rule, and many writers have been

TYPES OF ALLERGIC MANIFESTATIONS OF THE EYE AND ITS ADNEXA

1. Allergic conjunctivitis
   a. acute
   b. chronic
2. Vernal conjunctivitis
   a. corneal type
   b. lid type
3. Cataract
4. Sympathetic ophthalmia
5. Corneal ulcers
6. Focal eye reactions due to bacterial allergy
7. Tuberculous infection of the eye
8. Lesions of the retina and optic nerve
9. Visual allergy
10. Ocular headaches due to allergy

ORGANS AND TISSUES INVOLVED IN THE EYE

1. Peri-orbital tissues—edema
2. Skin of eye-lids and lid margins—urticaria, edema, contact dermatitis
3. Conjunctiva—allergic conjunctivitis
4. Cornea—allergic keratitis
5. Uveal tract—uveitis, cataract
6. Retina and choroid—edema with loss of vision
7. Optic nerve—edema with loss of vision.

struck by the clinical picture of vagotonia presented by their patients—a preponderance of the vagal over the sympathetic element in the vegetative nervous system with lessened suprarenal activity. Angelucci (1898) pointed out the frequency of vernal conjunctivitis in persons of a lymphatic type, defining a diathesis characterized by vasomotor lability, tachycardia, lymphoid hyperplasia, and general hypo-adrenalism (Angelucci's syndrome). After him many observers have noted dysfunction of the thyroid, parathyroid, suprarenal, and sexual glands (Lagrange, 1922–35, Santori, 1927, Lemoine, 1929, Lagrange and Delthil, 1932, and others). Vagotonia has been specially stressed by Guerra (1929), Mamoli (1930), Ferrari (1930), and Casini (1932), and it has been associated with infantilism, the status thymolymphaticus, eosinophilia, and a relative lymphocytosis (Rizzo, 1924; Gennaro, 1928). It would appear that the evidence is strong that vernal conjunctivitis is frequently, and by no means invariably associated with constitutional disturbances of this type; but it is weak if taken to imply that such a diathesis is itself causative. We are on safe ground only if we admit that these factors, about which we know very little, and that little vaguely and indefinitely, form a suitable soil whereon the disease may readily flourish.

The theory that vernal conjunctivitis is a manifestation of an allergy has the most definite evidence to support it, but even that is not conclusive. On general pathological lines such an etiology is possible, for the two types of lesions which occur are analogous to other conditions which are almost certainly allergic, the one conforming to the pathology of a phlycten and the other to a cutaneous eczema. The clinical evidence in favor of this hypothesis is considerable, namely, the tendency to attack the young, the seasonal occurrence of the attacks, and the type of secretion with the presence of eosinophils. The theory must stand or fall, however, on the evidence of specific hypersensitivity in affected persons, the demonstration of other symptoms characteristic of allergy with a familial tendency, and the response to treatment by exclusion of the allergen or desensitization to it; and while there is a considerable amount of positive evidence available, it cannot be said to warrant universal acceptance.

The existence of a specific sensitivity to pollens, animal inhalants, foods, and so on, has been investigated by several workers. Lagrange (1922), Fort (1923), Townsend (1923), Lemoine (1925–29), Weinstein (1931), and others, found that the great majority of patients were pollen-sensitive; others obtained indeterminate results (Teller, 1932), while still others (Guerra Paolo, 1929; Thommen, 1931) failed to confirm them. Lehrfeld (1925–32) in a large series of patients found 30 per cent sensitive to various allergens, when given intradermally in large doses, and exhibiting other allergic manifestations. He also obtained a recrudescence of the symptoms in the quiet winter period by instilling some of the irritant into the conjunctival sac. Its association with hay fever has also been stressed by Townsend (1923), with vasomotor rhinitis by Mamoli (1930), with asthma by Weinstein (1931), and similar evidence has been brought forward by Seefelder (1911), Kruckmann (1930), and others.

Acute conjunctivitis. The term, allergic conjunctivitis, is employed usually when referring to the acute inflammatory condition of the

conjunctiva which is seen in patients with hay fever. Here, the conjunctival mucous membrane contains cells sensitized to pollen and as a consequence, contact with pollen produces an allergic reaction. This is manifested by a conjunctivitis which may be reproduced easily outside of season by instillation of dry pollen or pollen extract into the eye. The degree of sensitivity and the extent of the contact will determine the severity of symptoms. They may be mild and scarcely noticeable in some patients, or be marked and cause considerable discomfort in others.

The most pronounced symptoms of this condition are itching, lacrimation, and some photophobia. These patients frequently report for examination wearing colored glasses. The secretion present is usually watery and thin or possibly slightly mucoid. The latter type is found, as a rule, in the morning on arising and shows a predominance of eosinophils upon examination of the stained smear.

Inspection of the eyes in these patients will reveal definite evidence of conjunctival inflammation, the degree of which depends upon the severity of the reaction. The vessels of the conjunctiva, both around the cornea and beneath both lids, are injected and the mucosa itself looks swollen or edematous either in its entirety or in localized areas. In the severer types, the lower lids may be swollen or puffy, due to the edematous involvement of the loose subcutaneous tissues.

Edematous, loose tissue beneath the lids is often hard to explain to the patients after a negative history of insomnia, excessive dissipation, or kidney disease. It then behooves the ophthalmologist to make a careful check for the offending allergens.

These characteristics may be more marked during hay fever season in all patients. It seems to be the consensus of opinion among allergists, and I have found it true in my practice, that the allergic patient is sensitive to a number of different allergens. Bags beneath the eyes occur more often in adults than in children. In a smaller percentage of patients the eye symptoms will predominate almost to the exclusion of the nasal symptoms which may be very slight or insignificant. This is the type of patient who consults the ophthalmologist first, because he believes that there is something wrong with his eyes. It is important that the practitioner recognize the possibility that this condition is allergic in character rather than attribute it to bacterial infection or to eye strain.

The differentiation of the type of conjunctivitis seen in hay fever from other forms of acute conjunctivitis is not difficult. The seasonal occurrence, the intense itching, and the absence of mucopurulent discharge, containing a predominance of neutrophilic leucocytes and bacteria, and the positive skin reaction to pollens, are sufficient to distinguish it from acute catarrhal conjunctivitis or "pink eye" due to infection.

Chronic conjunctivitis. Chronic conjunctivitis of the allergic type, and similar to that seen in patients with acute hay fever, is occasionally observed in those hay fever patients in whom the eye symptoms are especially predominant. In these patients the repeated conjunctival irritation results in a low grade inflammatory condition of the lids, which appear thickened and more or less continuously reddened. The acute inflammation subsides usually with the termination of the hay fever season but persists in a mild form throughout the year. The eyelids of these patients show a tendency to stick together on arising, due to the presence of a thickened mucoid discharge. Although the primary factor in these instances is usually a pollen, the possibility of sensitivity to some other inhalant, like dust, feathers, or orris root should be kept in mind, especially in those instances in which the eye symptoms are perennial in character. The diagnosis and treatment of this type is similar to the acute form.

Allergic conjunctivitis, of either an acute or chronic type, in some instances may be the result of sensitiveness to agents other than pollen. Examples of such agents are eyelash dyes, tints, cosmetics, and the different chemical solutions, such as butyn, pontocaine, atropine, bichloride, eserine, and pilocarpine. These products produce rather violent reactions in the eyelid and conjunctiva as a result of marked sensitivity. In this instance, the reaction is in reality like a contact dermatitis. Skin reaction by the scratch or intracutaneous

methods is negative, as would be expected. Cosmetics containing heavy metals, perfume, orris root, certain hair dyes, or even silk, may produce a similar reaction in sensitive individuals, although this is likewise uncommon.

Vernal conjunctivitis. There is little or no question among allergists or ophthalmologists as to the allergic character of the conjunctival conditions thus far discussed. Considerable controversy has arisen, however, concerning the possible allergic basis of the condition known as vernal conjunctivitis, also called "spring catarrh" or "vernal catarrh." This condition is a subacute or chronic form of conjunctival inflammation, which begins characteristically with the onset of the warmer months, particularly in the late spring or early summer, and persists usually as long as the warm weather lasts, which accounts for the use of the term "vernal." It is characterized clinically by itching and redness of the eyes, lacrimation, photophobia, and a ropy lardaceous type of discharge which causes the eyelids to stick together especially on arising in the morning. Symptoms are usually worse in the late evening and on contact with heat.

Depending upon the location of the lesions upon examination, two distinct types of vernal conjunctivitis have been distinguished: (1) The limbic or corneal type, characterized by the appearance of discrete vesicles occurring at the margin of the cornea. These may become confluent and completely encircle the corneal border, giving it an "icing" or "frosting" appearance. (2) The lid type involves the lids only. Lehrfeld distinguishes three separate varieties: a, simple follicular; b, cobblestone; and c, granuloma. These may be spoken of as separate varieties but some authors think these are just a continuation of the first form. These are all characterized by red eyes, lacrimation, heavy mucoid discharge, itching, and photophobia. Smears prepared from these secretions by Giemsa stain reveal the presence of eosinophiles in large numbers.

The two types, corneal and lid, rarely if ever co-exist in the same patient. The appearance and locations of lesions are different. Itching is less prominent and mucous discharge scantier in the corneal variety. This type usually disappears with the onset of cold

Pollinating Grasses during Vernal Conjunctivitis Season (from May 15 to September 15):

Grass Combination No. 1—Early Spring (May 15 to July 1)	
June grass	5
Orchard grass	2
Bermuda grass	1
Sweet vernal	1
Plantain	1
Grass Combination No. II—(June 15 to August 1)	
Plantain	1
Bermuda grass	1
June grass	1
Johnson grass	1
Timothy	4
Redtop	2
Grass Combination Mixture No. III—(August to September)	
Bermuda grass	4
June grass	2
Johnson grass	2
Plantain	2

Allergic conjunctivitis due to pollens from (August to latter part of September):

Combined Weeds No. I	
Short ragweed	5
Giant ragweed	2
Southern ragweed	1
True marsh elder	1
Burweed, marsh elder	0.5
Cocklebur	0.5
Combined Weeds No. II	
Russian thistle	2.5
West. water hemp	2.5
Lambs quarter	2.5
Pigweed	2.5

Allergic conjunctivitis most commonly seen from August on:

Combined Grass and Weeds	
Grass No. III	10 per cent
Combined weeds No. I	70 per cent
Combined weeds No. II	20 per cent

The allergic conjunctivitis which persists may be carried through the winter by vaccines, autogenous and occupational dusts.

weather, whereas the lid type usually starts in the early summer months, and ordinarily is due to the early pollinating grasses acting as the offending irritants. A number of these early grasses pollinating from May 15 to July 1, are June grass, orchard grass, Bermuda grass, sweet vernal, and plantain. Carried on from June to August are Johnson grass, timothy grass, and redtop. From August to September there is the continuation of Bermuda, Johnson, June, and plantain. The latter part of September the corneal or limbic type of conjunctivitis may disappear, but there will be a continuation of the lid type by irritations from pollination of short, giant, southern ragweed, truemarsh elder, burweed, cocklebur, thistle, western water hemp,

lambs quarter, and pigweed. Foods, house and occupational dust, and animal emanations, such as horse and dog dander, may act as continuous exciting factors throughout the year.

Cataract. The possibility that cataracts, especially the type occurring suddenly in young people, may be allergic in origin has been suggested recently. The antigenic properties of lens protein have been recognized for many years. Various experiments have shown, for example, that beef lens protein is identical in its antigenic properties with the lens protein of other animals, although different from other types of organ proteins.

In 1922, Verhoeff and Lemoine suggested that the inflammatory reaction of the eye or endophthalmitis, which occurred in certain patients after cataract extraction or after a second discission in children, might be the result of an allergic reaction to the lens protein left behind in the chamber. They called this type of reaction endophthalmitis phacoanaphylactica and established it as a clinical entity. The existence of hypersensitiveness in these patients was indicated by positive skin reactions to lens protein and also by the fact that injection of lens protein extract for purposes of desensitization was followed by rapid subsidence of the inflammatory reaction.

These findings have been fully confirmed by other observers, who likewise have shown that certain patients with cataract will give a negative skin reaction to lens protein before operation and a positive reaction afterward, especially if an endophthalmitis develops after operation. It is generally agreed, therefore, that the postoperative inflammation following cataract extraction is an allergic phenomenon and that desensitization with lens protein extract is an indicated and valuable procedure in these patients.

The relationship of lens protein to the development of cataract, however, is not defined as clearly. Attempts have been made to treat cataractous patients with lens protein extract and although either total arrest or definite improvement has been reported in a large percentage of patients, these results have not been confirmed experimentally and are not generally accepted. The only suggestive evidence of a relationship is the report of the successful production of certain lens defects in a strain of guinea-pigs, whose heredity had been followed for several generations and in which no lens defects had occurred previously. The mechanism by which these defects were produced awaits experimental confirmation.

That cataract also may result from an allergic reaction to proteins, other than lens protein, is indicated by the reports of patients in whom the cataract occurred in association with a definite allergic manifestation. The cataracts in these patients were always in association with atopic eczema.. Positive skin reactions were obtained in nearly all instances. These findings have prompted the application of the term, "allergic cataract," or "cataracts associated with allergy," to these cases.

In discussing the ocular antaphylaxis, Lemoine covered this subject very thoroughly with Verhoeff and McDonald. At the present time I am treating 7 patients with bi-weekly injections of lens protein[1] sterile solution of 2 per cent from cattle eyes. All these patients, varying in age from 35 to 72 years, have incipient cataracts. They were given a complete physical examination, and after the foci of infection had been eliminated as nearly as possible, special attention was given to the patients' endocrine balance and vitamin intake. They were started on a dosage of two-tenths of a cubic centimeter with increasing graduate doses to 10 cubic centimeters. It is too early, however, to evaluate this problem. This work has been done previously by other men claiming various results.

Sympathetic ophthalmia. The reason for the occurrence of an inflammation of a normal healthy eye in a patient who incurs an injury in the opposite eye has been the subject of considerable controversy. Experimental and clinical observations by Elschnig and by Woods have indicated the possibility that this condition likewise may be the result of an allergic reaction, produced by a hypersensitivity to the uveal pigment. The latter also has been shown to possess antigenic properties distinct from that of lens protein. As evidence of hypersensitiveness Woods reported the occurrence of positive intracutaneous skin

[1] Lens protein is manufactured by Sharp & Dohme of Philadelphia.

reactions to uveal pigment in patients with sympathetic ophthalmia, whereas control patients gave negative reactions. He found that negative skin reactions occurred in the acute stages of the disease, just as they did in the tuberculin allergy of acute tuberculosis. On the basis of these findings, Woods used uveal pigment therapeutically in patients with sympathetic ophthalmia and reported favorable effects. These findings, while distinctly suggestive, are not as yet generally accepted.

Corneal ulcers. Isolated cases have been reported in recent literature in which an ulcer of the cornea affected an allergic individual as the result of specific hypersensitivity. Lemoine in 1925 reported a series of 6 cases. Parlato reported an ulcer in an individual who had ocular symptoms in association with coryzal symptoms and who was found specifically sensitive to orris root. Allergic therapy including orris root desensitization proved effective. The appearance of such ulcers as the result of specific hypersensitiveness is rare and should be suspected only when they occur in a definitely allergic individual. The exciting allergens in Lemoine's cases were both pollens and foods.

Focal eye reactions due to bacterial allergy. There is ample clinical evidence to justify the suspicion that certain inflammatory conditions of the eye, notably iritis, are due to an allergy to bacteria present in such foci of infection as the sinuses, teeth, tonsils, gall bladder, etc. That these foci of infection have a definite etiological relationship is rather generally accepted and is proved by the frequency with which their eradication is followed by disappearance of the eye condition, and also by the occasional flare-ups or focal reactions which follow the removal of the infected focus, or the subcutaneous injection of a vaccine prepared from the bacteria cultured from the focus.

Many successful attempts have been made to obtain living organisms from the secondary focus in the eye. It is obvious, therefore, that the ocular inflammation is not produced by the bacteria themselves but is the result of the action of their toxic products.

Tuberculous infections of the eye. The relationship of allergy to tuberculous infections of the eye has been studied extensively. Such infections are always of endogenous origin and occur in previously infected individuals. The exact part played by allergy and immunity in relationship to these ocular infections is controversial.

According to Woods, conclusive evidence indicates that the phlyctenules of phlyctenular keratoconjunctivitis are the result of an allergic reaction of the sensitized surface of the cornea and conjunctiva which may result either from a small early tuberculous focus in the eye or as part of a general hypersensitiveness to tuberculoprotein from lesions elsewhere in the body. On the other hand, there seems to be no definite evidence to indicate that an allergic factor exists in tuberculous interstitial keratitis or in tuberculosis of the uveal tract.

Lesions of the retina and optic nerve. These structures are rarely the seat of primary allergic reactions. They may be involved secondarily as part of a general allergic reaction, as in the case reported by Bedell in which edema of the nerve head and retinal hemorrhages occurred as part of a serum reaction following the administration of tetanus antitoxin. In another case reported by Coca, simple edema of the left macula occurred each summer in an atopic patient who had gastrointestinal allergy and migraine.

Involvement of the retina by edema or of the retinal vessels (spasm) probably accounts for the ocular symptoms accompanying migraine (scotomas, photophobia, etc.). A similar explanation may be given for those isolated instances of diplopia, temporary blindness, or hemianopsia which are the result of allergy to foods like chicken or fish, although the exact mechanism is not known.

Some attempt has been made to attribute certain instances of retrobulbar neuritis to the pressure of the marked edema incident to an allergic reaction in the adjacent ethmoid or sphenoid sinuses. All 6 cases reported by Hansel cleared up with local treatment. These instances are the exception rather than the rule.

Visual allergy to light. This term has been applied to abnormal ocular reactions to ordinary amounts of light. According to Lehrfeld, "It is principally a physical allergy, not in

TABLE I.—DIFFERENTIAL DIAGNOSIS

	Seasonal	Secretion	Cytology	Itching	Lacrimation	Photophobia	Nasal secretion
Allergic conjunctivitis—drugs, chemicals, dust	Any time	Thin, watery	Not marked	Not marked	Marked	Yes	No
Allergic conjunctivitis—pollens, foods	Summer may persist	Thin watery	Eosinophils	Marked	Marked	Yes	Marked
Vernal conjunctivitis	Spring and early summer	Ropy thick	Eosinophils	Marked	Marked	Yes	Some
Bacterial conjunctivitis	All year	Thick mucopurulent	None	Some	Marked	Yes	No
Trachoma	All year	Thin watery	None	Marked	Marked	Yes	No

any way related to immunological sensitivity but certainly related to urticaria solaris and to urticaria dermographica. It is not an allergy in the sense that there exist antibodies or reagins which are clinically foreign to the tissue cells."

Lehrfeld points out that tolerance or intolerance and visual allergy to light is intimately associated with the pigment content of the choroid, retina, and iris and that when this is deficient, tolerance to light is also decreased. This can be corrected to a considerable extent by the addition of pigment in the form of tinted lenses. The use of such glasses has been found very valuable for this purpose.

Ocular headaches due to allergy. After a careful correction of the errors of refraction and a search for pathological conditions of the eye, the ophthalmologist is often unable to make a diagnosis of the patient's headaches. It would then be well to take a careful history of the patient with reference to foods, endocrines, vitamins, and so forth. It is well to keep in mind that the eye symptoms may be due to a nasal allergy giving the referred discomfort to the eyes.

DIAGNOSIS

A careful history is of the utmost importance. It gives leads to the offending allergens, which may be preseasonal, seasonal, or perennial. Eye secretion smears should be prepared by means of Giemsa stain. Tests should be made for food, pollen, dust, and so forth; and there should be cut and scratch tests, intracutaneous, passive transfer, mucosal, ophthalmic, and patch tests, and the leucopenic index should be taken. Special attention should be given to endocrine balance and vitamin intake in order to establish correctly the basal metabolic rate. A questionnaire should be given to the patients to take home and to fill out, and a complete physical examination of each patient should be made.

The diagnosis of vernal conjunctivitis is usually not difficult except in the early stages. The characteristic localization of symptoms to the eyes, the presence of itching, the seasonal occurrence, the typical appearance of the conjunctival mucosa, and the presence of a thick, ropy, eosinophil discharge are diagnostic. In its early states, it may be confused with hay fever or some type of bacterial conjunctivitis. The presence of nasal symptoms, the strict correspondence of the symptoms to the pollinating period of a known plant and the occurrence of definite skin test evidence of pollen sensitivity are sufficient usually to differentiate hay fever of the ocular type from vernal conjunctivitis. Bacterial forms of conjunctivitis are distinguished by the severity of symptoms and the presence of a mucopurulent discharge which contains many neutrophils and bacteria. The only chronic condition of the conjunctiva with which it may be confused occasionally is trachoma. This condition is readily differentiated, however, by the complete absence of itching, the absence of eosinophils in the discharge, which is not of the ropy type, and the lack of a seasonal incidence.

TREATMENT

Symptomatic. Secretion should be removed from the eyes 3 times a day by irrigation with a dropper. The patient is given a 16 ounce bottle of solution containing 1 grain of salicylic acid, 2 grains of zinc sulphate, 1 dram of sodium borate, 1 ounce of aqua camphora, and distilled water sufficient to yield 16

ounces. Although the hydrogen ion concentration of the eye secretion is always high, this seems to give more relief than straight alkaline solutions. Ten minutes after each eye is irrigated, there should be the instillation of 1 drop in each eye of the following solution: 1 grain of suprarenin bitartrate, 1 grain of zinc sulphate, and saturated solution of boric acid sufficient to yield 1 ounce. One per cent holocaine solution may be added to this mixture, if desired to control pain. This is followed by an ice pack.

This, in my hands, has given a great deal of relief. The patient is also asked to take 1 to 2 capsules a day. Each capsule is composed of one-eighth grain of powdered neo-synephrin, one-eighth grain of sodium phenol barbital, 2 grains of aspirin, and 3 grains of powdered lactated calcium. This dosage is for adults and is used in proportion to age for children. Glasses with polarized lens and calabar lens seem to give better results for photophobia than ordinary colored lens. It must be kept in mind that these are palliative, symptomatic measures and a search should be instituted for all the offending allergens, pollens, foods, and dusts.

The allergic method of treatment may include dry therapy, the avoidance of the etiological factors, the eradicating of some therapeutic infection, or the application of a nonspecific therapy. Any one, or a combination of these various types of therapy, may be required to obtain results.

SUMMARY

From the review of the literature and my personal experience in this field, it seems certain that allergies play a very definite rôle in ophthalmology.

Most cases of vernal catarrh occur in children. When the age of puberty is reached symptoms of vernal catarrh usually disappear and it is at this time that we have an entire change in the endocrine system of the child. Unfortunately, there is no accurate means of determining the function of most of the glands of internal secretion and knowledge of the normal biochemical disturbances is so limited that in most cases it is impossible to come to a definite conclusion.

It would seem that the endocrine balance, with metabolic and biochemical function disturbances, is closely associated or the underlying cause of the allergic manifestations. Allergic patients improve rapidly when endocrines are given with the desensitization process.

CONCLUSIONS

1. Allergy plays an important rôle in ophthalmic entities.

2. Endocrine disturbances are usually present with allergic phenomena.

3. Endocrine therapy helps the allergic patient.

4. The factors of endocrine balance, metabolic and biochemical functions, vitamins, and heredity, all play a part in the allergic patient's manifestations.

I wish to express my thanks to Drs. French K. Hansel, Albert Lemoine and John L. Meyers, for their invaluable assistance in compiling this paper.

REFERENCES

1. Arrthus, N. M. Injectous repeteis de serum de cheval chez le lapin. Compt. rend. Soc. de biol., 1903, 55: 817.
2. Elschnig, A. Studien zur sympathischen Ophthalime II. Die antigene Wirking des Augenpigmente. Arch. Ophth., 1910, 76: 590.
3. Gibson, W. S. The etiology of phlyctenular conjunctivitis. Am. J. Dis. Child., 1918, p. 188.
4. Gifford, S. R., and Steinberg, A. A. Allergic and toxic properties of lens protein. J. Am. M. Ass., 1925, 85: 351.
5. Hansel, French K. Allergy of the Nose and Paranasal Sinuses. St. Louis: C. V. Mosby Company, 1936.
6. Lemoine, Albert N. Conjunctivitis and dermatitis due to butyn. Am. J. Ophth., 1927, 10: 2.
7. Lagrange, H. Conjunctivitis of anaphylactic origin. Presse méd., 1923, 31: 380.
8. Lehrfeld, Louis. Recent advances in vernal conjunctivitis. J. Med. Soc., N. Jersey, 1937, 34: 731.
9. Magendie. Ehrlich's Gesammelte Arbeiten. P. 332. New York: John Wiley & Sons, 1906.
10. Schoenberg, M. J. A contribution to the experimental study of ocular anaphylaxis. New York State J. Med., 1914, 14: 493.
11. Uhlenhuth, P. Zur Lehre von der Unterscheidung verschiedener Eiweissarten mit Hilfe spezifiche Sera. Koch's Festschr., 1903, p. 49.
12. Verhoeff and Lemoine. Endophthalmitis Phacoanaphylactica.
13. Idem. Hypersensitiveness to lens protein. Am. J. Ophth., 9, 5: 1922.
14. Walker, I. C. Personal communication. J. Med. Research, 1917, 37: 51.
15. Wessely, K. Weber. Anaphylaktische Ercheinungen an der Hornhaut. Muenchen. med. Wchnschr., 1911, 58: 1713.
16. Woods, A. C. The application of immunology to ophthalmology. Arch. Ophth., 1932, 53: 4.

THE PRESENT STATUS OF SURGERY OF THE LACRIMAL SAC

RALPH O. RYCHENER, M.D., F.A.C.S., Memphis, Tennessee

THE patient with chronic dacryocystitis, presenting clinically an epiphora and regurgitation of mucopurulent secretion into the conjunctival cul-de-sac, brings to the ophthalmologist a condition which is of decided interest and importance. The constant watering of the eye is most annoying and prevents comfortable and ordinary use of the eye at any time, while the integrity of the eyeball is in constant jeopardy as the smallest abrasion, such as follows a foreign body in the cornea, may result in infection, ulceration, and loss of the eye.

This type of inflammation has resulted in a variety of procedures designed by radical means to eliminate the focus of infection in the tear sac, such as chemical destruction by cauterization, excochleation, Paquelin or galvanic cautery, and finally excision or extirpation. All of these procedures have had ardent advocates and have been successful in eliminating the backwash of purulent material into the conjunctival sac, but they have been notoriously unsuccessful in ridding the patient of his epiphora which is the main symptom for which he seeks relief. Statistics from various competent clinicians demonstrate that epiphora persists in as many as 65 to 70 per cent of patients who have had the tear sacs removed, and that nearly as high a percentage of patients are dissatisfied with the results of operation.

The so called medical treatment of lacrimal stenosis by the passage of probes to the nose through the normal passages of the lacrimal drainage apparatus has in general given only temporary relief. One may be elated at one sitting to find that relatively large probes can be passed through the stenosed areas after which fluids pass easily into the nose, only to find at the next visit of the patient that a subsequent reaction has produced a constriction that does not permit the passage of even the smallest probe without considerable trauma and bleeding. This in effect influences the formation of false passages, scar tissue proliferation, and increased stenosis with considerable discomfort to the patient and, as a rule, leaves him with no permanent benefit.

These experiences have caused most of us to seek some method of re-establishing normal communication between the conjunctival sac and the nose by means of some operative procedure which promises a permanent and successful result. Such a result is one in which epiphora and mucopurulent secretion from the lacrimal sac have been eliminated entirely, and in which the patency of the drainage system can be demonstrated by the passage of fluorescein or some similar colored solution from the surface of the conjunctiva to the meatal area in the nose. It is not enough to force fluid to the nose by means of a syringe; the fluid should travel as do the tears in a natural, unaided way. To obtain this end it is essential that the puncta, canaliculi, and internal common punctum be left in a perfectly normal condition; for if the capillary attraction of this portion of the drainage mechanism is disturbed, one is doomed to disappointment in proceeding to operate on the sac itself. There has been heretofore too widespread an attack upon the puncta and canaliculi by means of slitting and excision when the pathology really lay more deeply in the depths of the sac and lacrimal canal.

These mistakes need be made no longer as the use of a radio-opaque medium such as lipiodol, bismuth in albolene, or iodipin, injected into the lacrimal sac will by x-ray demonstrate the position of any stenosis in the passageway. The first is an excellent solution but the injection should be made on the x-ray table as lipiodol passes through the lacrimal sac rather rapidly. If no stenosis is

Presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

present in the lacrimal sac or canal, one should consider the possibility of hypersecretion of the tears as a cause for epiphora before attacking the puncta or canaliculi. This can be demonstrated by the Schirmer blotting paper test, other individuals being used as controls; and if the output of the lacrimal gland is definitely increased, one can treat the gland with x-ray, excise the accessory lobe of the lacrimal gland, section the ductules, or inject the sphenopalatine ganglion.

If stenosis of the lacrimal sac or canal is demonstrated by x-ray, some procedure to restore normal function of the drainage apparatus is indicated. Various techniques to accomplish this end have been devised. Many were discarded and later revived to good effect. In the main the acceptable methods may be listed as: (1) The external operation, in which an anastomosis with sutures is made through a skin incision between the lacrimal sac and the nasal mucosa; (2) the internal, whereby an opening into the sac is effected from within the nasal cavity; (3) the combined operation of Toti-Mosher, in which the surgical attack is from both outside and inside; (4) the transplantation operation, whereby the sac is lifted from its bed through an external incision and transplanted through a new bony opening into the nose; and (5) giant probing, in which an opening is forced from the sac to the inferior or middle meatus and a drain is left in place.

External operation. The external operation dates from the early part of the eighteenth century when an English surgeon, Woolhouse, reported a technique which was later revived in 1904 by Toti and has since been popularized by Depuy-Dutemps and Bourguet. Chandler, in his comprehensive review of this subject, states that it is the most refined of all operations on the lacrimal sac and ranks first in the statistics on successful results.

It is the procedure with which my associates and I are most familiar, and in our hands it has been successful in 27 consecutive operations. These have been done on 24 patients ranging in age from 6 to 72 years. Six operations followed acute attacks of dacryocystitis at intervals of 1 to 6 months with no untoward reaction. Fistulas, which were present in 3 cases before operation, gave no further trouble afterward. One operation was done on a patient with congenital syphilis who also had a perforation of the septum. One young female patient had an obliteration of the lacrimal fossa following an automobile accident, which destroyed the bridge of her nose and necessitated many plastic operations for its restoration; the result in her case was as perfect as the others. A middle-aged male patient lost his right eye and suffered mutilation of his face following a shot gun accident, and the atrophied tear sac was located in a mass of scar tissue a full centimeter from its natural bed in the lacrimal fossa. Although the sac was reduced to the size of a pea, it was possible by traction sutures to make an anastomosis with the nasal mucous membrane and this also resulted successfully.

In one patient only have we been disturbed by the formation of a scar. This was in one of our early cases, a middle aged female of Grecian lineage, who developed a keloid type of bridle scar, which we later attempted to improve by plastic repair but with which we were never quite satisfied. In checking the final results of our limited series we were greatly surprised to find that this patient's answer was the most enthusiastic of all; she was perfectly satisfied with the physiological and cosmetic result.

Many operators with much more clinical material have found this procedure satisfactory in from 95 to 100 per cent of cases. Inasmuch as this is an operation which the ophthalmologist without special training or apparatus can learn to do satisfactorily from the diagrams and description, the technique will be given in some detail here, and the student is referred further to the excellent article by J. J. Corbett. It was this article which induced us to adopt the procedure which in our hands has been quite satisfactory.

OPERATIVE TECHNIQUE

Anesthesia is obtained by the hypodermic injection, approximately one hour before operation, of morphine one-half grain to one-eighth grain and scopolamine, one one-hundredth to one four-hundredth grain, depending on the age and size of the patient.

Block anesthesia with 1 per cent solution of novocain with adrenalin is made over the supra-orbital, anterior ethmoidal, and infra-orbital areas as well as in the line of incision and deeply in the bed of the sac.

A cotton or gauze plug saturated in 10 per cent solution of cocaine and adrenalin, 1:1000, is inserted in the middle meatus of the nose near the anterior tip of the middle turbinate in order to produce anesthesia and ischemia of the nasal mucous membrane, and is left in place until the nasal mucous membrane is exposed by removal of the lacrimal crest.

Illumination of the field of operation is an important factor and I use an electric head lamp for this purpose, although a concave head mirror with a good source of light is sufficient. Bleeding is controlled by the suction tip, a point which has been a great aid in shortening the time of operation.

The skin incision is that commonly used in most external sac operations, starting about 5 millimeters above the internal palpebral ligament, passing down over its bony insertion (about 5 millimeters to the inside of the inner canthus) in a line parallel to the lacrimal crest, and terminating at a point opposite the entrance of the nasolacrimal canal.

The internal palpebral ligament is cut, the superficial fascia, muscle, and deep fascia are divided, and the sac exposed and reflected outward as it is lifted out of its bony groove. The sac may be retained in this position by means of a retractor, while a similar retractor holds the structures on the opposite side of the wound well over toward the median line. The retractors are held by one assistant while the other assistant works in the field with the operator. I have found that the use of the ordinary lacrimal sac retractor will obviate the necessity for one assistant if the retractor prongs are entered more deeply into the wound and allowed to engage the subcutaneous tissue just over the sac wall and just above the periosteum of the anterior lacrimal crest.

The next step is the complete removal of the anterior lacrimal crest by means of a chisel. When the nasal mucous membrane is exposed, the bony opening is enlarged with Citelli and Kerrison forceps, making an oval-shaped window with the long axis from 10 to 12 millimeters in the vertical plane, while the transverse diameter varies from 8 to 10 millimeters. Lately, Arruga has advocated making the opening with a motor-driven trephine. However, the technical difficulties encountered at times with such an instrument are considerable and I have not been impressed with it in my personal experience.

At this stage a longitudinal incision is made in the wall of the sac. The pus or mucus, if present, is removed, and the inner lining of the sac is swabbed with tincture of iodine. The nasal plug is then removed. A vertical incision is made in the nasal mucous membrane, equal in length and directly opposite the sac incision. Three sutures of No. 0000 catgut on small half curved atraumatic needles are passed by means of a small artery forceps through the posterior tip of the nasal mucous membrane.

These 3 sutures are held taut while a cut 2 millimeters long is made at right angles to the upper and to the lower end of the vertical incision. This forms a flap which facilitates approximation to the posterior lip of the sac. The 3 sutures are drawn through the posterior lip of the sac incision by the small artery forceps, tied, and cut close. Thus the posterior wall of the new lacrimal drainage canal is formed.

After the same fashion 3 more No. 0000 catgut sutures are passed through the anterior lip of the nasal mucous membrane with the same forceps and held taut while the right angle cuts, similar to those in the posterior lip, are made. These sutures are drawn through the anterior border of the sac, and, in addition, through the periosteum and overlying soft tissues. The sutures are then carefully tied. It is this last little feature of the Depuy-Dutemps technique—the suspension of the anterior wall of the canal from the overlying tissue—which aids in maintaining the patency of the new lacrimal canal. Three silk sutures or a subcuticular suture closes the skin incision. An ordinary eye bandage is applied, but there is no intranasal dressing. Sutures are removed on the third day, and the bandage is discontinued thereafter. The patient leaves the hospital on the second day.

Postoperative treatment has rarely been necessary although occasionally some crusts will have to be removed from the nose. In our series of 27 cases we have had but one postoperative hemorrhage which required packing the nose, and the nasal pack in this patient was removed the morning following the operation with no further complication. On only 2 occasions have accessory ethmoid cells been encountered. These were exenterated and the operation was carried out in the usual manner without complication. In no case as yet have we found it necessary to remove the anterior tip of the middle turbinate or operate on a deflected septum, although we recognize that in some patients there will be nasal pathological processes which require preoperative treatment or surgery. In 1 patient, previously operated upon elsewhere by the combined method, it was necessary to remove by cauterization an adhesion between the septum and the middle meatus.

Paul Chandler has recently advocated a modification in this operation by preparing 3 mucous membrane flaps instead of 2. He made an incision in the tear sac in the form of a T, with the horizontal incision about 3 millimeters from the upper border extending from the anterior to the posterior edge of the sac. The vertical cut extended from the center of the horizontal incision down to the base of the sac, and as far into the duct as possible. A similar incision was then made in the nasal mucous membrane exactly opposite the sac. Thus 3 flaps were formed, a posterior, a superior, and an anterior. These he united with small silk sutures, usually 1 posterior, 2 superior, and 1 anterior, resulting in an almost solid tunnel of mucous membrane running from the sac to the nasal cavity, and the top of the sac was held up in its proper position. Twenty-two operations which he performed in this manner were all successful.

Internal operation. The first report of an operation by the intranasal route was by Caldwell in 1893. The method has been extensively advocated by West who made a large opening into the duct above the inferior turbinate and then later modified it to uncover the entire lacrimal sac without opening the duct. Various other modifications in the matter of reflection of mucous membrane flaps have been followed by good reports from Halle, Bookwalter, Daily, and others. This operation can be done with satisfaction but presents considerable technical difficulty if properly done. It falls in the class of operations which demand a high degree of intranasal technical skill, the only excuse for which is that no external incision is made. It is not an operation for an ophthalmologist, and many prominent rhinologists feel that it is not as safe a method as the one previously described. Perforation of the orbital wall with cellulitis of the orbit and loss of visual acuity has been reported.

Combined operation. The combined operation comprised the external technique of Toti with some intranasal modifications of Mosher, which included the removal of the anterior tip of the middle turbinate and curettage of the anterior ethmoid cells in all cases. In addition, any deviation of the septum was corrected by preliminary operation.

A bony window was made through the lacrimal fossa, the exposed nasal mucous membrane excised, and a similar area cut from the approximating wall of the lacrimal sac. The anterior edge of the sac was sutured to the cut edge of the periosteum over the nasal bone but there were no sutures connecting the nasal mucous membrane with that of the sac.

Failures were common because of poor approximation of the openings in the sac and nasal mucous membrane, closure of the osteotomy, or plugging of the newly formed opening by granulations. Successful results ranging from 40 to 100 per cent have been reported.

Transplantation. The transplantation method was devised by Forsmark who lifted the lower part of the sac from its bed, severed it at the duct, and then drew the end of the sac into the nose through a small opening in the lacrimal bone. This was modified by Speciale-Cirincione who made the bony window through the anterior lacrimal crest, thereby avoiding the ethmoid cells. This has lately been revived by Stokes who shortened the time of the operation by using an electric trephine which drilled a hole through the ascending process of the maxilla. Stokes re-

ported very favorably on a series of 43 cases. Patency of the sac is essential and the constriction must not be present above the point of severance else the result will be a failure. It will be an excellent operation for cases of chronic dacryocystitis in which a mucocele is present, but will not serve when the sac is atrophic, when papillomas are present or when the sac wall is involved.

Giant probing. Under giant probings are grouped all methods by which a probe is forced into the nasal cavity, either through the original duct passageway or through a new opening in the lacrimal bone, following which some metallic stylet is left in place for varying periods of time. Such operations were suggested by Koster, Ziegler, Fowler, Dean, and others. Probably the best procedure along these lines is that reported by Spratt who slit the lower punctum and under gas anesthesia introduced a Callahan tube on an obturator through the lacrimal passage. The obturator was withdrawn leaving the thin silver tube open at each end, the lower end under the inferior turbinate and the upper end flush with the conjunctival cul-de-sac. This may be left in place for months and extracted when desired by grasping the lower end with a hemostat and withdrawing it by a rotating movement which crushes the thin silver tube and permits painless removal. Success with this instrumentation has been high.

From the statistical reports available on the operations heretofore described it seems certain that some form of dacryorhinostomy should be substituted for the operation of excision or extirpation of the sac in cases of chronic dacryocystitis. This latter operation should be reserved for tumors of the lacrimal sac and, to my mind, that condition should be almost the sole reason for its application. In this connection one should be on guard not to mistake for tumor of the sac the hard, unyielding mucocele sometimes encountered in stenosis of the duct. In our series of 24 patients, there were 5 who some time during their treatment were suspected by my colleagues and myself of having malignancies of the sac. The instillation of saline into the sac, the application of heat externally, and persistent massage over the mucocele finally resulted in the discharge of a viscous, glairy fluid from the sac through the canaliculi on the conjunctival surface.

It may be justifiable to extirpate the sac previous to intra-ocular surgery, when one is pressed for time, but one may be lulled into a feeling of false security by doing so. Virulent cultures of pneumococci have been grown from the conjunctival cul-de-sac for weeks after such an excision, and it is justly questionable whether dacryorhinostomy is not the choice of procedure even in this situation.

SUMMARY

The purpose of this paper has been to review briefly the various methods to bring about a favorable solution of the intractable problem of chronic dacryocystitis. Results will vary with various operators and each will continue to use the method which has done well in his hands. But for those who have not been successful in treating this condition and for those who still do extirpation in preference to some form of dacryorhinostomy, I offer the choice of several techniques, any one of which has its good points. For the beginner in this field of surgery, the external operation with sutures, which join the mucous membranes of the sac and the nose, will prove to be quite satisfactory. Once he has mastered this technique he may proceed to modifications; but one hesitates to change the form of surgical procedure which has given uniformly satisfactory results in his hands, hence I believe that most new converts will continue to use it.

BIBLIOGRAPHY

1. Arruga. Ann. d'ocul., 1929, 166: 580.
2. Asbury. Tr. Am. Acad. Ophth. & Otol., 1927, p. 85.
3. Bookwalter. Arch. Ophth., 1920, 49: 568.
4. Chandler. Tr. Am. Ophth. Soc., 1936, 34: 240.
5. Corbett. Am. J. Ophth., 1928, 11: 774.
6. Daily and Daily. Am. J. Ophth., 1929, 12: 1.
7. Depuy-Dutemps. Ann. d'ocul., 1921, 158: 241.
8. Ellett and Rychener. South. M. J., 27: 339.
9. Forsmark. Sitzungsb. Ver. d. Schwed. Augenuertztl., Stockholm, 1917.
10. Gifford. Ophth. Rec., 1909, 18: 454.
11. Macmillan. Arch. Ophth., 1932, 8: 831.
12. Mosher. Laryngoscope, 1915, 25: 739.
13. Speciale-Cirincione. Clin. ocul., 1913, 13: 1369.
14. Stokes. Nebraska State M. J., 1935.
15. Toti. Ztschr. f. Augenh., 1912, 27: 115.
16. Weeks. Arch. Ophth., 1932, 7: 443.
17. West. Tr. Am. Ophth., Soc., 13: 654.

THE 1938 CLINICAL CONGRESS

THE AMERICAN COLLEGE OF SURGEONS IN RETROSPECT AND PROSPECT ON ITS TWENTY-FIFTH ANNIVERSARY

FREDERIC A. BESLEY, M.D., F.A.C.S., Waukegan, Illinois

THIS, the twenty-fifth anniversary of the founding of the American College of Surgeons, is a milestone in its progress. Let us review the accomplishments of its first quarter of a century. Have the years of planning and of laboring to uplift the standards of surgery produced results? In what directions has the influence of the College been strongly and courageously wielded? In what other directions could that influence have been more powerful, more beneficial, more significant, had our vision been clearer and our convictions stronger?

This is a time for critical self-analysis by the Fellows of the College. We are starting on a new stretch of our journey. We have an opportunity to re-define our objectives and to re-intensify our efforts in the directions in which we appear to be pursuing the right course. Today is the future of which some of us had a vision 25 years ago. The realities around us now are the fulfillment of those dreams of yesterday. In all respects they do not meet our expectations, but not one of us will question that without the dreams the realities would have been far less satisfying. Therefore, we must focus our eyes today on the next quarter of a century. We must dream and plan anew so that the record of the next 25 years' accomplishment, upon which the new generation of surgeons will look back in the year 1963, shall be equally as inspiring, and equally as substantial and impressive as the one we now review.

We have important advantages today over the dreamers of 1913. These are the results of their great foresight. We are solidly organized for smooth functioning. We have accumulated experience in co-operative effort which gives us confidence. We have acquired a background, a sense of stability, and a feeling of permanence that equip us for accomplishing much more in the future than we have in the past. We have won in the eyes of the profession and of the public a position of unquestioned leadership in our field. This last achievement compels us, as trusted guardians of the sick and injured, to insist that surgeons be guided by the highest professional and ethical considerations. Upon us devolve responsibilities not for our own fellowship alone, but for all members of the profession. Looking to the future, we see no lessening of responsibilities. Rather, as our ideals and our purposes become more widely understood, we see increasing dependence upon the College, by both the profession and the laity.

Our founder and organizer, Franklin H. Martin, set us an example of courage and of persistence that is a wellspring of inspiration. Consider the obstacles he faced in trying to weld a profession, composed of individualists, into a guild organized to curb unethical practices by individuals, and to encourage a co-operative ideal that would necessarily destroy individualism of the old, self-sufficient type. The College stands as a living monument to his success in overcoming these obstacles. He took the spirit of democracy and the spirit of co-operation as ingredients, and mixed a potion strange to the taste of the average surgeon of his day. Many of them drank reluctantly. But time and circumstances, and his own gifts of diplomacy and persuasiveness, were on the side of Dr. Martin, and those surgeons learned to like the potion as they felt its stimulating effects.

In organizing the College Dr. Martin and his associates followed the principles of demo-

Address of the Retiring President, presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

cratic rule, distributing the executive power among many individuals through a representative Board of Governors and a Board of Regents who would be free from any direct self interest or monetary gain. Thus they assured adaptability and the constant influx of new ideas. The basic principles involved in the welfare of the patient will not change, but the modes of applying these principles are changing constantly with new conditions.

As an illustration, there has arisen of late the important question of graduate training in general surgery and its allied specialties. The College has always been actively interested in the formal education and early training of the surgeon. But lately surgery has been tremendously complicated theoretically and practically by new discoveries, new methods, and modern developments in technique. To obtain the desirable command of knowledge and the necessary skill for precision and safety, the student of surgery today must add a more supervised training to his clinical preparation. Not enough qualified hospitals, however, are providing opportunities for him to gain such practice. Therefore, the College is assuming the responsibility, which rightly belongs to it, to determine the exte t of the need and to encourage hospitals to inaugurate a graduate training program in surgery, or to enlarge and improve the one they may have at present. The Board of Regents of the College, by raising the requirements for admission to fellowship for this and succeeding years' graduates, obligated our organization to aid in providing opportunities for the extended training that these higher standards demand.

The established departmental activities of the College, since they were carefully based on pressing needs for reform or for research, have produced actual, tangible improvements in surgical and hospital methods and environment. Perhaps we should consider whether any of these departments have accomplished the purposes for which they were founded to such a degree that their task is finished. Must the College ever be seeking new avenues of service, or does the future hold boundless opportunities for some of these established departments?

The Department of Hospital Standardization—one of our strongest divisions of endeavor, the achievements of which are so well known that they need no reiteration before this audience—what will be its future? Hospitals, like the human beings who work in them, betray no signs of reaching a state of perfection, despite our energetic efforts to improve them. This is an admission we must make at the outset. It means that the work of the hospital department of the College will never be finished. Changing times will bring only new problems. The department must co-operate with the Committee on Graduate Training by continuing to survey, analyze, and plan for the developing of graduate training opportunities in acceptable hospitals. In assuming this responsibility the department is insuring its own happy destiny by multiplying its opportunities for present and future service to the patient in the hospital.

The Department of Clinical Research has likewise made rapid progress and insured its permanent usefulness by seeking and making the most of opportunities for service. Great educational and practical benefits have resulted from the promotion and surveys of cancer clinics, the registry of bone sarcoma, the collection of records on 5 year cancer cures, the surveys and standardizations of medical departments in industry, and the efforts to improve the management of fractures. The Fellows of the College are essentially practical, realistic, clinically-minded surgeons, and in the future they will be guided more and more by the evaluations of advances made in clinical surgery as presented by the Department of Clinical Research. In the past 4 decades much of the advance in surgical therapy has been in the technique of operating, and it may be predicted that in the future increasing study and research will be devoted to the cause, pathology, and progress of those diseases which are now and will later be found to be amenable to surgical treatment. The Department has before it an ever-widening horizon of usefulness and influence in contributing to the advance of scientific surgery.

The field representatives of the College deserve special acknowledgment for the surpassing value of their services. These expe-

rienced, highly trained men have worked diligently to secure first-hand, accurate information of many kinds from many sources. Their findings have influenced the determination of policies by the Board of Regents, and the execution of these policies by the administrative executives. The proficiency of these investigators is increasing. In the future it will doubtless be necessary to increase their number as the scope of the College activities broadens to include new avenues of service. It can be stated with some degree of finality that this branch of the College work will grow and become more vital.

Another activity that has bright prospects for continued growth is the Library and Department of Literary Research. A valuable service, constantly improving, is being rendered. The usefulness of the package library service cannot be overstated. In the future the service of the library will be utilized and appreciated even more. By co-operating in securing additions to its collections, the individual Fellow can help to increase the department's ability to serve the fellowship.

The College has used the congress and conference method extensively for educating the profession and the layman. While this work is not handled in a specific department but is participated in by all departments, it is an established activity that, for our purposes today, needs separate consideration. It is an activity that has reached astonishing proportions. The Clinical Congress of the American College of Surgeons is one of the great educational events of the year on this continent. Few regular occurrences of any nature are accorded more attention by the press. This shows that the College has been able, with the co-operation of the press, to arouse a demand for news of advances in surgery. When to this public educational value is added the instructional value to the surgeon himself, it is safe to prophesy that the annual Clinical Congress will have a brilliant future to correspond with its brilliant past.

The miniature clinical congresses, or Sectional Meetings, the idea of which was conceived 20 years ago, have performed in their lesser spheres the same service as the larger congress and have the same outlook for continued success. The first was held in Butte, Montana, the beginning of a series of meetings which have introduced the College and its work to the American people in their home communities. In the smaller group more discussion and freer expression are possible, and the scientific sessions and operative clinics held in the smaller cities have been valuable supplements to the Clinical Congresses held in the larger cities. The community health meetings, for obvious reasons, have been particularly well attended in the smaller communities, and have unquestionably stimulated confidence in the doctor. Confidence, so engendered, will help the public to seek medical advice more frequently and follow it more intelligently. The public should not be expected to accept medical practices on faith. There is nothing occult or mysterious about modern medicine; its scientific basis should be made more clear to the layman to help him to distinguish between impostors and competent doctors, and between haphazard and correct procedures.

This introduces the subject of public education which cannot be too strongly emphasized as a field which must be cultivated more systematically by the medical profession. The College has already prepared the ground in a more or less incidental fashion through Clinical Congresses, Sectional Meetings, and the publicity arising naturally as a result of its various activities, especially Hospital Standardization. The community health meetings have provided an excellent impetus. However, more of a direct nature must be done. The practice of medicine has never been so prominent in the day's news as it is now. Back of it is a gradual awareness by the public that great things have been occurring in the field of medical science, an awareness that we ourselves have tried to develop; and people want to know more about the new discoveries, the new theories, and the new procedures. They also want to know why they are not all benefiting from these discoveries as they should.

Capitalizing upon this interest, authors and publishers are turning out books and articles that are being read avidly. And what is in them? Much sensation and distortion of facts, merely to enhance their readability and

increase their selling power. Some of the current, popularized, medical literature is good and is truly educational, but much of it exaggerates the flaws which we all know exist, while it fails to convey the impression it should of the sound features of modern medical practice. As is always the case in such a situation, the attack is read by 10 persons and only 1 will read the answering defense, if the profession is sufficiently aroused to prepare one for publication. The result is that we may expect a weakening of public confidence unless direct measures are taken to interpret the doctor aright. When the profession is misrepresented as being more interested in its economic security than in healing the sick, the remedy is to let people know in a more systematic way than we have heretofore attempted, that we are surgeons first and earners afterward; for this is true of the great majority of members of the profession.

This brings us to a consideration of the unfortunate practice of fee splitting, which furnishes the public with one reason for the accusation of commercialism. Fee splitting is diminishing, we believe, but it is still quite prevalent. The College has fought it from the beginning. Candidates must sign a pledge not to indulge in it; hospitals in which it is countenanced are not approved; and other professional groups have likewise acted against it. In some instances the agitation has only degraded an open practice to a surreptitious one, so more stringent measures are needed to abolish it completely. The competent physician should have a high enough estimate of his own worth to convince his patient of the value of his services and should not expect what amounts to commission on a sale deducted from the surgical fee. Such a practice endangers the patient because it fosters bargaining, and the only way in which it can be completely eradicated is to educate the public to its evils. The Board of Regents of the College have done much to decrease the practice of fee splitting. It is their clear and pressing duty to eliminate it altogether.

The doctor is handicapped because he cannot advertise his honesty, his philanthropy, or his spirit of service the way a man who operates a business can, and so the critics are unanswered when they point to a practice such as fee splitting, which is really indulged in by only a small minority. Consequently, the medical profession has to use extraordinary measures to regulate the unethical minority, in order that aspersions may not be cast through them upon the entire membership. Through its own organizations such as the American College of Surgeons it has provided for self-policing, as well as for the developing of programs for broader and constantly improving service to the patient. To acquaint the public with the work the College is doing is to enlighten it concerning the scientific, humanitarian, and public-service attitude that characterizes the typical surgeon who through his fellowship and support decides the scope of its activities.

It is true that the great advance shown by medicine, scientifically speaking, has not been quite equalled by medical practice as applied to the needs of all classes of society. This problem, however, is not by any means peculiar to the medical field. It exists in government, in industry, and in education. The progress that has been made in improving the lot of the individual is generally obscured by the far greater progress in theoretical and factual knowledge in almost any field. A parallel can be drawn between this state of affairs and the noticeable lag between almost any man's actions and his professed principles and ideals. We think that the medical profession is trying as hard as any other, and perhaps harder than most, to solve the problems arising out of uneven distribution of income which makes its services easily available to a few people, but not obtainable by the great majority in the lower income brackets. It is unquestionably a fact that physicians and surgeons give more service for which they receive no money compensation than any other class of people in modern life, and they give it gladly because of the humanitarian motives that govern them.

The American College of Surgeons has always recognized the advantage of united effort by all groups acting to improve the care of the sick and injured and to promote preventive medicine. This again might be considered a special activity in which all depart-

ments participate. Its program has been actuated by a desire to enable the surgeon to play in this joint effort the important part for which his background and services qualify him so that the effort as a whole may be more effective. All plans of the College for the future are being made in this same co-operative spirit.

As for the science of surgery, the College has an ambitious project which typifies its zeal to spread knowledge. This refers to the Hall of the Art and Science of Surgery. As yet there is no distinct building in which to house it, but a site has been acquired on which to build some day; and we dreamers of 1938 see upon it, not the old structure that now stands there, but a fitting monument to the inspiration and zeal of those who have led in the research work of the College. Nor is the project wholly dependent upon imagination for sustenance. An impressive nucleus for the collection of exhibits already exists. It is well arranged for display and bids fair in the not too distant future to outgrow the accommodations for its exhibition in the Administrative Building. The Hall of the Art and Science of Surgery will some day need a building of its own, and many of us, we hope, will live to see it rise.

Chiefly, it is as a moral rather than a material force that we see the College of the future. Our ambition for it is that the quality in which it shall most excel will be that of worthy leadership. It needs no artful phraseology or extensive logic to point out that there is grave need for medical statesmen in the ranks of organized medicine. Men who have a broad vision, and the diplomatic and judicial qualifications which make for leadership, are required to cope with the difficult problems confronting them, which cannot be regarded with indifference and equanimity. It is the duty of the American College of Surgeons to discover and to develop leaders who will make the influence of the profession felt in improving the whole environment of human life. A large part of that responsibility is distinctly medical, for a high average of health is essential to progress. We in the medical profession are compelled today, for our own good and for the good of society, to pool our problems with those of other social agencies, to the end that the fundamental factor of adequate medical care be a strong impetus to their constructive efforts. We must maintain a flexible mentality. Good health fosters economic self sufficiency, good citizenship, everything that makes a happy life. Therefore, it is our duty to welcome and not to resent the interest being shown in high places in the conduct of medical affairs; it shows appreciation of the importance of the work we are doing and can do. As an organization of surgeons we have before us a great opportunity to throw our experience and our intimate knowledge of the problems back of any effort to provide better care for the patient, with the insistence that the direction of the effort be placed in the hands of a competent medical personnel.

If we make the most of our present opportunities, we face a busy, eventful, new quarter of a century. That is what we want—is it not?—strenuous working programs ahead to call forth our best efforts, to develop us individually and as a strong fellowship striving to serve our generation. The College was erected on an ideal for service; so far we think we have lived up to that ideal to the best of our collective abilities. The prospect is that we shall continue to go forward by holding to that ideal. Hopefully and optimistically we set forth on our new quarter of a century for "it is better to journey hopefully than to arrive."

OUR COLLEGE MANDATE

A Tribute to Allen B. Kanavel

WALTER CHIPMAN, M.D., F.R.C.S. (Ed.), F.A.C.S., Montreal, Canada

ON May 5 our College celebrated its twenty-fifth year, its quarter-century of service in these two Americas. Very reasonably, I think that we may be proud of the achievement. However, "Wisdom is justified only of her children"; or, in other words, this very success carries with it a commensurate, an increasing responsibility.

While we have already 12,700 of these children, a large fellowship, mere numbers or mere size may be, in and of itself, no special virtue. Quality is the thing that counts, and a set regard for our abiding fitness in this changing world. And it is of this aspect of our college life that I shall speak.

You will remember that our Charter of Incorporation, in somewhat quaint phrase, extends "To All To Whom These Presents Shall Come Greeting." And to this the 450 Founders annexed our constitution and our by-laws, bequeathed to us this College mandate. And we Fellows implement this mandate, give our hand upon it (as the name implies;) accept this trust, the privilege, the authority, and the obligation. For as a College we solemnly promise to do what we can for the betterment of surgery, its training and its practice; to improve our hospitals and our medical schools; to make of our College a great clearing house, wherein a sound knowledge and a safe technique may be advanced, may be tested, stored, and distributed. It is indeed a reform from within, undertaken to make our surgical world a safer and a better place; the welfare of the patient, the alpha and the omega of it all.

And this is no small domain or no light undertaking. Even in our approved hospitals there are two and one-half million operations every year, and how imperative is the need of a wise, a vigilant, and a critical stewardship. I need not say here that good surgery is a difficult, a responsible, and a painstaking business. To secure this for rich and poor alike is the purpose of this mandate, and it is the sum and substance of our College life.

Our College mandate then; and with a special reference to the life and work of the late Allen B. Kanavel, distinguished Regent.

And first in the name of the College, I extend an added welcome to the Class of "38," the 539 Fellows who have been admitted this evening. Oddly enough, your numbers are approximate to the number of our Founders—the Founders of this College. And our one wish is that you prove yourselves as good as they. This Fellowship confers a twofold blessing: you donate yourselves to our College lifestream, a carefully matched transfusion, and in return, to each of you are thrown open the gates of a larger and more useful life.

Thucydides said of the ancient Greeks that they "possessed the power of thinking before they acted, and of acting too," and it is just this power of thinking and of acting that has set its seal upon this later Magna Græcia—our own America.

I can think of no better axiom to govern our College life; the *sine qua non* of any achievement. No one can gainsay that our Founders were men of thought and action. It is sometimes said of Franklin Martin, that he dreamed three dreams and lived to make them all come true. And these three were: (a) the publication of the journal, SURGERY, GYNECOLOGY AND OBSTETRICS, in 1905; (b) the creation of the Clinical Congress of Surgeons of North America, in 1910; (c) the founding of the American College of Surgeons, in 1913.

The journal and the congress were the successive steps that led to the foundation of our College. How clearly it now appears to us! Franklin Martin, the great harbinger of our College mandate, now rests from his labors. We owe to him and his, a debt we never can repay.

Oration on Surgery, presented before the Clinical Congress of the American College of Surgeons, New York, October 17–21.

And the truth is the surgical world had great need of such a mandate. May I place before you, very shortly, the proof of this, the setting of that earlier time.

Though the American Medical Association had been founded in 1847 for the betterment of medical education and the control of irregular practice, very little was achieved until in 1904 it appointed a special council for the study of this Medical Education and Hospitals. At that time there were in this Country, 162 medical schools, more than in all the rest of the world put together. And is it any wonder that Henry S. Pritchett, president of the Carnegie Foundation said of these schools, that nearly half were entirely inadequate; and Abraham Flexner declared that our "Medical education includes something of what is best, and all of what is worst, to be found among civilized nations."

And during those years surgery, perhaps, was the greater offender. For brilliant as were many of its exponents, the general standards were low, the prevailing methods slap-dash and ill informed with no general oversight or organization.

Samuel Gross of Philadelphia had published the first complete *System of Surgery* in 1859. Writing in 1876 he declared that "there is not a medical man on this Continent who devotes himself exclusively to the practice of surgery." This was the year, (1876), of the Founding of the American Gynecological Society. It was not until 1880 that the American Surgical Association was formed, and only in 1903 the Society of Clinical Surgery.

As an illuminating corollary we observe that in 1873 there were only 149 hospitals in these United States. In 1934, 61 years later, the number is given as 6,334, with their own hospital association formed in 1899.

This addition of 95 hospitals a year was merely the result of supply and demand, for there developed an enormous increase in the work of general surgery and its specialties, with the rapid creation of sixteen special surgical societies or associations. In all conscience it was rapid—really catching, like the measles. These sixteen societies, however, were separate and distinct, determined in part by the points of the compass, and in part by the special character of the work. Separate and distinct I say, there was little dealing with one's neighbor, for there was as yet, no common nexus between them. You must forgive these facts and figures for it is only in this way that we gain a true perspective, realize the difficulties that beset us. Assuredly there was a large and disjointed house to be set in order—in Flexner's phrase, "something of what is best,"—and at the beginning of the century abundant need of our college mandate. *Vere scribere est per causas scribere*—to write truthfully is to write in the light of the causes of things. So in 1913, the stage was set.

Two ways were open to us—either to follow tradition and exact a scholastic examination, again an exclusive hierarchy; or on the other hand to create from the beginning a surgical commonwealth, the members to be chosen for their character, actual work, and experience.

I shall always believe that, very fortunately, our young College chose the latter course. For in so doing it drew together the many surgical associations, gave them an axis as it were, and also secured the influence and the weight of the whole profession.

After all, in any arena a "punch" is the thing that counts, and the mandate to impress itself, must have this general strength behind it. Moreover as we all know, an academic distinction may confer no skill in practice; even the author of a surgical text may be, as a surgeon, just a weariness to the flesh.

I make no apology for the early College requirement. Accordingly in the first 2 years we admitted to Fellowship 2,024, established at once a powerful nucleus, to control as it were, our cellular life. Speaking for the College we have had, as yet, no cause to regret it.

Again in my judgment, our College gains no small measure of strength from its democratic form of government. As you know, 50 Governors are elected each year for a triennial term; 17 of these represent the 15 surgical societies, the Army, and the Navy, while 33 are chosen by the Fellows at large. I think you will agree that this makes for a fair, a strong, and cohesive organization.

And now concerning the mandate, how much have we done? What is the accounting of our stewardship?

We are all familiar I take it, or we should be, with the multiple activities of the College. I shall not enumerate them other than to indicate their wide range of usefulness. I have spoken of our College as a great clearing house, and this truly it has become. For examples, it receives from special committees, annual reports of clinical research, of the standardization of hospitals and clinical laboratories, and of all the many problems that confront a surgical training and practice. Here, too, is our own Journal with the INTERNATIONAL ABSTRACT OF SURGERY; the *Bulletin;* a library of 25,000 volumes, with current monographs and periodicals and its Department of Literary Research and, thank you, a "package library" which I am using now. The College has a palatial home; it has held 28 clinical congresses and nearly 200 sectional meetings; it has provided community health programs, round table talks, and a legion of lectures, both popular and scientific.

Why it reads, this curriculum, even as a liberal education. True it has cost the College three and three-quarter millions of dollars. An expensive mandate if you will, but the improvement in our hospitals alone is well worth the money.

This hospital standardization represents the largest work of its kind that has ever been undertaken, the largest, the most far-reaching, and beneficent. In a true sense a hospital may be considered the fairest measure of any civilization, for it really shows how we treat the sick and the afflicted, and whether or no we are in any practical way, our brother's keeper. This campaign, begun 21 years ago with only 89 hospitals meeting the requirement, now shows 2,621 fully approved. Read Malcolm T. MacEachern's textbook, *Hospital Organization and Management*, published 3 years ago.

From the first this College has been intensively engaged in education, the education of ourselves, the laity, and the profession; it is and always has been a great post-graduate School. If any proof were wanting, just read the program of this annual meeting in New York. Everything is here, clinical, technical and scientific; and it is no 8 hour day I can assure you. The sorrow is that one cannot be in two places at once, for with this embarrassment of riches, the great difficulty is to choose.

Our College then is a great post-graduate school; and in consequence, and for this very reason, it is intimately concerned with all medical education. During these years we have lived in the very midst of an American renaissance, and with truth it may be said that this College has borne a share in the great reform. In this time what a change has been wrought in our medical education! You cannot make bricks without the proverbial straw, and now we are indeed proud of our 87 recognized medical schools.

Our chief concern, however, is with the young graduate, the embryo-surgeon. How is he to secure the requisite training, both in theory and in practice? How is he to spend the years between his graduation and his fellowship? These are the long lean years of his so called "graduate training," the most critical and the most important of the whole surgical business.

Samuel Butler enunciated a great educational truth when he said "don't learn to do, but learn in doing." And this mandate so expressed, has been for several years of urgent interest to the College. Various committees have been formed and have studied the many aspects of this important question. The junior candidate group was a step in this direction, and as from January 1, 1938, all applicants for Fellowship must have at least 3 years of hospital training and experience. "To learn in doing" under control and supervision; and, Fellows of the College, we have promised to find the place.

Progress is a sign of life; we cannot stand still. It seems to me that in this best and natural way we raise the College requirement and make the path straight toward an entrance examination for the Fellowship. Personally I believe in such an examination. Surgery is a science as well as an art, and at some time in his apprenticeship, the candidate is to be examined in the basic sciences—anatomy, physiology, and pathology, while later, if you will, he is to present his case reports. The average man is lazy and indifferent—most of us are average—and he needs such an objective, such a stimulus, to make him work. I have experi-

enced it myself, I also have seen it; and I know.

The American Board of Surgery, established nearly 2 years ago, amply corroborates this undertaking. In this way then, we educate and train our future Fellows, and peradventure by so doing we may silence the criticism of, may even satisfy, the dyed-in-the-wool academic mandarin. In any case, we benefit ourselves in this appeasement.

Dr. Richard C. Cabot, of Boston, recently observed that the greatest single curse in medicine is the curse of unnecessary operations. Well, the above is the remedy to lift this curse even from the mind of the austere physician; and in raising these standards, we are merely redeeming our promise, fulfilling the terms of our College mandate.

The strength of it all, of course, is derived from the individual fellow, his character, his education, and his work. To the extent of his sixpence, the success or failure of the College, is determined by each and every one of us. And just here how apposite is Carlyle's enunciation that, "what you are, thunders so loud I can't hear what you say."

May I quote to you the following: "The failure of any Fellow to conserve the ideals of professional honor, of service to the public, and of self-improvement, will impair more than we realize, the prestige of the College." Thus spoke Allen B. Kanavel in his presidential address here in this city, 7 years ago.

From the beginning, our College has been blessed with outstanding men, men who have guided its policy and given it impetus and inspiration. These have been our "prophets in Israel," and this Chicago surgeon was one of the latest and by no means the least, of these. We do well to learn from such men, to study their lives, their influence, and example.

Born in Kansas in 1874, Allen Buckner Kanavel was graduated from Northwestern University College of Liberal Arts, at the age of 22, and three years later he took there (cum laude), his medical degree. After 6 months of graduate study in Vienna, he returned to Chicago, serving first as an interne at the Cook County Hospital, before becoming associated with the department of surgery at Northwestern University Medical School. Here he was to spend the working years of his surgical life. Certainly he began at the foot of the ladder, for during the first year he merely supervised the patients' recovery from the anesthetic and was given no opportunity whatever even to observe a surgical operation. However, nothing could dampen his ardor and enthusiasm, and there is a strong satisfaction in recalling, that not so many years later, 19 to be exact, he became professor of surgery and chairman of the department, in this, his old School.

Endowed with skilful hands, he revealed during these first years an enquiring mind and a special aptitude in research.

Very early in his career he became impressed by the haphazard treatment of severe infections of the hand, and so he was led to undertake his famous dissections of the hand and forearm, using the injection of bismuth paste, to determine the relation of the tendon-sheaths, the lymphatic and fascial spaces—the natural channels of invasion. He was engaged on this work for some ten years, and in 1912 he published the monograph, *Infections of the Hand*, now in its seventh edition and a recognized authority throughout the world.

And this was only the beginning. The long list of his contributions to our surgical literature reveals a wide range of investigation and a continued interest in all research. In his practice he was perhaps best described as a specialist in many fields, equally at home in the axilla, head and neck, and the abdomen. His operative work was neat, resolute, and resourceful and Lord Moynihan was led to declare that in any serious operation upon himself, this surgeon was the man to do it. No mean tribute I can assure you! Moreover there were other qualities of the artist in him as expressed not only through his hands, but also by his unusual gift in writing and in speech. He was an admirable teacher, and an outstanding exponent in his chosen profession.

In the midst of this active professional life, Dr. Kanavel found time, or made it, for many additional activities. He was one of the five founders of the journal, SURGERY, GYNECOLOGY AND OBSTETRICS, and served from its inception to his death on its editorial staff, for the last three years as its editor in chief; he was

treasurer of the Clinical Congress during its seven independent years; and of the College, he was a founder, a governor, and a regent, and active member of many committees and finally its president in 1931–32. Through it all, he was always the "man on deck," ready, purposeful, and competent. I can imagine no finer tribute than the one paid to him by his Journal on his sixtieth birthday in commemoration of these services, and of his 35 years of surgical teaching and practice.

A full life indeed and full to its tragic end!

All this work of course was the great center of his life, but there were nevertheless certain "margins of leisure" round about it; and these margins only the more clearly revealed the lovable character of the man. He was always a great reader and genuinely attached to books. It is in his library that I best remember him. Again, he was fond of games, and of the open and the sky; and especially in his later years, Nature in her changing moods, was a great solace to him.

The end came in a motor accident at the age of 64 years. He has passed from the sight of men; but he lives "in minds made better by his presence, and in thoughts that pierce the night like stars."

COMMENTS ON THE 1938 MEETING

HENRY W. CAVE, M.D., F.A.C.S., New York, New York

THE annual Clinical Congress of the American College of Surgeons is intended, primarily, to be an educational event. Therefore, its success is proportionate to the gains in knowledge and in understanding which those who attend it receive. Of course, it is quite impossible to calculate exactly how much more knowledge the 1938 delegation carried away than they brought with them, but it is entirely possible to judge of the aggregate educational benefits by analyzing the spirit shown at the meetings.

It was stimulating, in the first place, to note the interest in the subject of education for surgery itself, especially graduate education and training. Concern for the preparation of the new generation of surgeons shows appreciation of the increasing complexity of surgical problems. In the second place, it was impressive to see surgeons, who are recognized among the most competent in the profession, eagerly watching other surgeons, perhaps less well known, perform operations and demonstrate procedures. This bears testimony to the fact that the surgeon recognizes that the continual interchange of opinions and experiences is essential to keep him up-to-date and to maintain the required self-confidence for successful surgery. That the Clinical Congress presents a welcome opportunity for such interchange was most apparent, and it seems that every year the surgeon's zeal to learn grows in intensity as more knowledge accumulates.

A change is quite noticeable in the type of knowledge which the surgeon is seeking at the Clinical Congress. In the past he wanted to watch famous surgeons at work or to see unusual and extraordinary operative procedures. Of the 1938 Clinical Congress audiences, however, one surgeon remarked: "They seemed to be not so much interested in brilliant, individual results as in a consideration of the commoner problems which confront a surgeon in his daily practice." This means that the mere fact that a problem is common does not imply that it is easy to solve, or that, being constantly confronted with it, a surgeon becomes confident that he has learned all there is to be learned. It seems that the opportunities for widening knowledge afforded by this Clinical Congress is steadily increasing its educational value.

Fifty-two hospitals participated in the clinical program, the largest in point of clinics in the history of the Congress. Most of the operative clinics were well attended. A feeling is growing, however, that these have a disadvantage, in that only a few persons standing close to the operating table can see the details of operation. Surgery is becoming less dramatic and more physiological; the dry clinics and demonstrations, together with the scientific sessions and symposia, seem to provide the best media for dissemination of information. Presentation of a subject from all the different points of view, that of the surgeon, perhaps the specialist, the radiologist, the pathologist, the anesthetist, and others, gives opportunity for correlation which is invaluable.

The symposia on cancer, fractures, urological infections, surgical procedures on the handicapped patient, industrial medicine and traumatic surgery, and obstetrics and gynecology demonstrated the progress that has been made in the diagnosis and treatment of these various branches of surgery. The evening meetings, which were addressed by outstanding surgeons, some of whom were foreign guests, were well attended and the subject matters were received enthusiastically. The midday round table conferences were a new feature this year, and were outstandingly successful because of the opportunity they provided for more informal discussion than was possible at the larger meetings.

Wednesday was given over to the Brooklyn Chapter of the American College of Surgeons. In the Brooklyn hospitals a most thorough and complete clinical program was carried out, and the participation of our Brooklyn neighbors added much to the success of the Congress.

Chairman of the Committee on Arrangements.

Among the distinguished guests from abroad who presented papers at the Congress were William H. Ogilvie, M.D., F.R.C.S., of London, England, who spoke on "Cancer of the Stomach"; Professor Hans Finsterer, of Vienna, who read a paper entitled, "Results of Repeated Operations upon the Stomach, Especially Gastrojejunal Ulcers"; and Professor Paul Werner, who described the Wertheim operation for cancer of the uterus. Mr. Ogilvie was granted an honorary fellowship.

Motion pictures again proved themselves to be valuable means of instruction. They were presented almost continuously and large audiences were always in attendance.

The link between the surgeon and the hospital, which constitutes his workshop, was again emphasized by the holding of the Hospital Standardization Conference in conjunction with the Clinical Congress. This important branch of the College activities is undoubtedly not appreciated sufficiently by the average surgeon; but those who attended the Clinical Congress and noticed the large and enthusiastic audiences at the hospital sessions received an insight into the value of Hospital Standardization.

The relation of the surgical profession to the public through the press has long been considered an important aspect of the Clinical Congress, both from an educational and an interpretive point of view. The local committee on public relations aided the chairman of the committee on public relations of the College in co-operating with the press representatives in the preparation of articles, thus avoiding misinterpretation of scientific facts.

The Committee on Arrangements is most grateful to those, who took part in the programs, for their unfailing co-operation; and to those, who attended the Congress, for their enthusiastic reception.

TWENTY-FIRST ANNUAL HOSPITAL STANDARDIZATION CONFERENCE

MALCOLM T. MacEACHERN, M.D., Chicago, Illinois

THE twenty-first annual hospital standardization conference, held in New York City in connection with the Clinical Congress of the American College of Surgeons, was exceptionally well attended; and it was noteworthy for the great amount of instructive and inspirational material which was presented.

Hospital executives showed special interest in the discussions of the College program to increase opportunities for graduate training in surgery and the surgical specialties, and gave assurances of their co-operation. This subject is treated in an article by the chairman of the Committee on Graduate Training for Surgery which appears on another page.

At a joint meeting with the Greater New York Hospital Association 5 of the more important subjects of general interest to hospitals today were discussed: graduate medical education, hospital insurance, standardization of equipment, financial safeguards for endowment funds, and the place of the voluntary hospital in society. In presenting the latter subject, David H. McAlpin Pyle, president of the United Hospital Fund of New York City, said that the element of competition between government and voluntary hospitals should gradually be lessened as it becomes evident that the two types of institutions are really complementary; the one assumes the bulk of the burden for hospitalization of patients of the lowest income class and of those afflicted with illnesses of long duration, and the other serves primarily the needs of those patients who can afford to pay all or something toward the cost of their care. Particularly constructive was his suggestion that the voluntary hospital make available, on a semi-philanthropic basis, the benefits of modern medicine and surgery to the middle classes through both the hospital's in and outpatient departments. This would remedy the fundamental defect in present day hospital service which tends to confine such benefits to the rich who can pay well for them and the indigent who can pay nothing.

The value of organized voluntary service in hospitals and the co-operation of governmental and voluntary agencies in promoting the welfare and care of the sick is not only desirable but possible under conditions of co-operative leadership in the community. Between them there must be no conflict, is the belief of Dr. S. S. Goldwater, commissioner of hospitals, New York City.

Hospital problems of practically every nature were discussed at the various sessions of the conference, and an entire afternoon was devoted to demonstrations of administrative and technical procedures in local hospitals. At the opening session the progress of hospital standardization was briefly outlined and the customary announcement was made of the list of approved hospitals, based upon the 1938 survey. The list showed a total of 2,664 hospitals fully and provisionally approved. The increase over the 1937 figure of 2,621 hospitals is not large; but more new institutions are included than the difference would indicate, inasmuch as approval was withdrawn from a number of hospitals which had shown laxity in observing certain of the requirements of the Minimum Standard for Hospitals.

Some hospitals were not rated or were reduced in rating because their administrators did not measure up to the requirements of adequate training and experience in hospital administration; some because of evidences of fee splitting; a few because of extension of the privilege of hospital facilities to so called "irregular" practitioners; and others because of incomplete medical records, the use of nurses' aids to perform duties for which they are inadequately trained, and other deficiencies. The announcement redemonstrated the fact that approval is not automatically retained; but continuous effort by the hospital is necessary to remain on the approved list.

The increasing determination to solve the maternal morbidity and mortality problem by constructive measures, which will insure better care, was evidenced in the devotion of an entire session to the discussion of the care of the mother and newborn in a general hospital. This symposium was preceded by the presentation of the minimum requirements of the American College of Surgeons for the obstetrical department in a general hospital.

Another general subject which was emphasized, and an entire session of discussion concentrated upon it, was the training of hospital executives. More and more the necessity is being appreciated of methodic instruction and systematic practical training for persons to whom the management of the hospital is entrusted. Hospital administration is a highly specialized profession. The political appointee, who has no firsthand knowledge of hospital problems, cannot possibly direct a hospital in such a way that its maximum potentialities for service may be realized, irrespective of the quality of his general educational and personal status.

Medical records were discussed, as in previous years, in a joint conference with the Association of Record Librarians of North America, as well as in round table conferences. This subject is one which it is necessary to emphasize continuously because complete medical records are not only a means of determining medical progress, but are themselves, if properly used, a factor in furthering advances. Unfortunately, all hospitals have not yet recognized the importance of such records. In a few cases correction of this one deficiency would entitle a hospital to a place on the approved list.

In the discussion of the effect of physical conditions in the environment of the patient as related to his case, and the further influence of these conditions on the personnel concerned, special reference was made to the subjects of proper lighting, air-conditioning, noise control, color, and other factors which may have a direct or indirect bearing on the progress of disease and convalescence, and on the morale of the hospital personnel.

Of major importance was the discussion of trends in nursing education and nursing service, and the progress which has been made in evaluating criteria basic for good nursing service in the hospital. It is apparent that the art and science of nursing is developing a higher level of standards.

The general tenor of the talks and discussions at the 1938 conference was that hospitals, like most other institutions in this era, must recognize the changing order, but must hold fast to the gains which have been made and seek to build upon them. The path of progress for the hospital is clearly marked along certain fundamental lines such as higher qualifications for all types of personnel, more carefully planned organization, greater attention to medical records both in preparation and use, wider coverage of scientific and clinical problems through medical staff conferences, bettering of physical facilities, an increasing sense of obligation in the training of all types of medical and hospital personnel, and a growing spirit of co-operation with all agencies whose efforts are directed toward improving human welfare. All of these considerations are inherent in the principles of Hospital Standardization, which has been the most prominent factor in hospital progress in the United States and Canada for the past 21 years, and which promises the patient constantly improved hospital care as new developments arise and prove their practical value.

GRADUATE TRAINING FOR SURGERY AND THE SURGICAL SPECIALTIES

DALLAS B. PHEMISTER, M.D., F.A.C.S., Chicago, Illinois

THE subject of graduate training for general surgery and the surgical specialties was emphasized at the Hospital Standardization Conference and at several of the scientific sessions of the Clinical Congress. The program of the American College of Surgeons is aimed not only toward increasing the opportunities for graduate training, but also toward improving the quality thereof. The subject was presented in considerable detail, and was heartily endorsed by the many speakers who contributed their views. Unquestionably, all agreed that this program is a great potential power toward insuring steadily rising standards of surgery which will benefit the profession, the patient, and the public in general.

In planning a program of such scope and significance, it is to be expected that there will arise some differences of opinion as to the best methods to be employed. It is gratifying that so few criticisms have been forthcoming, and none of these have been of an obstructive nature, but have been the natural result of differences in physical plants, and of differing views as to how the desired ends may be attained; in fact, these criticisms have usually originated from misunderstanding. Through conferences and discussions the College has sought to reconcile the various viewpoints as to details of procedure in order that a program may be developed that is workable and yet flexible enough for adaptation under varying circumstances. Some believe, for instance, that the sort of opportunity for graduate training, which the College considers ideal, cannot be created except in university connected hospitals or very large hospitals with university affiliations. These conditions will gradually be supplied either by plans which are being devised for basic science training in university laboratories, or by co-operation between universities and hospitals through the exchange of residents so that a wider range of experience may be afforded.

There is no denying that the large city hospital, connected with a university, has an advantage in providing graduate training, since clinical and academic facilities are abundant and highly organized. This is no reason, however, for confining graduate training to such institutions. In the first place, the surveys made by the College prove that they do not provide enough opportunities to fill the existing need for adequately trained surgeons. In the second place, there are some strong arguments in favor of the less centralized, and really more typical smaller institutions as training grounds. In the third place, the communities outside the medical centers are in need of surgeons with good basic science education and some training in the specialties who wish to acquire training in general surgery which can best be gained in the hospital of average size and average equipment.

There is no intention, in striving to improve graduate training, to encourage all medical graduates, who aspire to become surgeons, to seek opportunities in university connected hospitals. Rather there is a pronounced desire to stimulate the medium sized hospital in the medium sized community to devise ways and means of combining its advantages, as a typical field for practical experience, with the facilities for basic scientific study and specialized experience offered by the medical school hospital. Basic science training may be had independent of affiliations with the preclinical departments of medical schools. In other words the greatest effect of the whole program can be, if the hospitals and medical schools rise to their opportunity, to decentralize graduate training for surgery, and to make it possible for medical graduates to acquire in the medical center a well rounded, basic science background which they can ap-

Report of the Chairman of the Committee on Graduate Training for Surgery.

ply under competent supervision in the average sized hospital, perhaps even in their home community. Surgeons so trained are more likely than not to remain in such communities, and thus there may result a more decentralization of surgical skill than now exists. The need is acute for more direction in the final stages of a surgeon's training, and for more consideration of just how he is to use his training in the place where he is needed most.

Admittedly, the problems are many. But as one speaker said at the Congress, most of the problems will be removed automatically by the passage of time, since recent graduates in medicine have a much better foundation upon which to build. For a short time, however, some concession must be made to arguments for existing methods, such as training through apprenticeship, when no better system is available and when the senior surgeon is competent and conscientious.

In all fields of life today the trend is toward systematization and organization for efficiency and for progress. Surely in a field in which human life is at stake, methods which are haphazard and unco-ordinated should be unhesitatingly outlawed. The large concepts of safer surgery, better surgery, and increasing conservation of human life demand for their realization that hospitals, medical schools, and the surgical profession unite to further a correlated system of training for surgery which will insure to every community a surgical service of unchallenged quality.

SYMPOSIUM ON CANCER

PRIMARY PULMONARY MALIGNANCY

Treatment by Total Pneumonectomy

Analysis of 79 Collected Cases and Presentation of 7 Personal Cases

ALTON OCHSNER, M.D., F.A.C.S., and MICHAEL DeBAKEY, M.D., New Orleans, Louisiana

UNTIL recently carcinoma of the lung has been considered a relatively infrequent condition. However, recent studies demonstrate that pulmonary malignancy is not only a common occurrence but is one of the most frequent carcinomas of the body. This increase in incidence of bronchogenic malignancy is undoubtedly both apparent and real, as evinced by autopsy series from the German Clinics. Junghanns found an incidence of pulmonary carcinoma of 1.67 per cent of all autopsies performed from 1893 to 1927. The incidence of primary pulmonary carcinoma in all malignancies found at autopsy was 14.27 per cent during the period from 1893 to 1897. Seyfarth found increases in the incidence of pulmonary carcinoma from 5.01 per cent during 1900 to 1906 to 8.75 per cent from 1919 to 1923. During the first half of 1924 there was an incidence of 15.5 per cent. Jaffé, of Chicago, believes that pulmonary carcinoma represents 11.47 per cent of all carcinomas, and that pulmonary carcinoma was second in frequency only to carcinoma of the stomach and of the intestine. Frissel and Knox, in a series of 3,659 autopsies, found 588 cases of carcinoma of which 39 were carcinoma of the lung, thus representing 6.6 per cent of the total carcinomas and 1.06 per cent of the total autopsies. D'Aunoy, Pearson, and Halpert reported that of 6,000 necropsies on persons over 1 year of age, performed in the Charity Hospital in New Orleans, primary carcinoma of the lung occurred in 70, or 1.1 per cent, and was almost as frequent as primary carcinoma of the biliary tract or of the pancreas. In 1,244 autopsies performed at the Touro Infirmary in New Orleans there were 259 cases with carcinoma. Twenty-three of the carcinomas originated in the bronchus. The incidence of bronchial carcinoma in the total autopsies was 1.8 per cent, whereas that in all carcinomas was 8.8 per cent (36). It is evident, therefore, that the frequency of pulmonary carcinoma is high. The fact that in Jaffé's cases it was second only to carcinoma of the stomach emphasizes the necessity for its clinical consideration.

Although it is controversial whether the increase in pulmonary carcinoma in recent years is apparent or real, the German autopsy statistics would indicate that the increase is actual and not only apparent. There are several explanations for the actual increase in the incidence of pulmonary malignancies, most of which have not been satisfactory. A number of theories have been suggested. Winternitz, Wason, and McNamara, because of the presence of metaplasia in the bronchial mucosa of persons dying from influenza, suggested that this change is a precancerous lesion. The inhalation of irritating gases such as war gas or gas originating from the increased use of motor cars has been proposed as an etiological factor. In our opinion the increase in smoking with the universal custom of inhaling is probably a responsible factor, as the inhaled smoke, constantly repeated over a long period of time, undoubtedly is a source of chronic irritation to the bronchial mucosa. In addition to the actual increase in pulmonary malignancy, there is unquestionably a relative increase in those localities where routine postmortem examinations previously have not been made. This is due probably to the fact that the condition has not been suspected in many cases and adequate diagnostic procedures have not been employed. The recent development of thoracic surgery has stimulated interest in intrathoracic lesions. This, with the development of specialized methods of diagnosis, has facilitated the recognition of pulmonary malignancies.

From the Department of Surgery, School of Medicine, Tulane University.

Presented in the Symposium on Cancer, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

PATHOLOGY

It is generally agreed that the lining cells of the alveoli rarely, if ever, give rise to malignant neoplastic growths. Consequently all carcinomas of

the lung are bronchiogenic. Carcinomas of the lung have been variously classified according to their morphological appearance. However, the most logical classification to us is that proposed by Béla Halpert. This classification is based upon the development of the cells lining the bronchi and this adequately explains the histological structure of all primary pulmonary carcinomas. Normally, the cells lining the mucous membrane of the bronchial tree represent varying degrees of differentiation and specialization of the original entodermal cells. According to Halpert, "The epithelial cells covering the mucous membrane of the bronchial tree from stem to the minute branches are entodermal cells with a varying degree of differentiation and specialization. Apparently the undifferentiated entodermal ancestor cell is capable of developing into ciliated cylindrical epithelium, goblet cells, cuboidal cells, arranged into acinar and tubular structures producing a serous or mucous secretion, indifferent cells, lining the ducts of these glands, and into another kind of cuboidal or low cuboidal cells without cilia which line parts of the terminal bronchioles. In addition to the variety of cells just enumerated there are, beneath the ciliated cylindrical and goblet cells, a varying number of other epithelial cells which, like the basal cells in the epidermis, are lined up along the border toward the tunica propria. They are the cells from which the single layer of ciliated cylindrical and goblet cells are replenished. These cells, which may be called 'reserve cells,' are the parent cells of the ciliated, cylindrical, and goblet cells. In addition they naturally also possess the qualities of their ancestor cells in that they may differentiate into any kind of epithelium that an entodermal cell is capable of producing" (Fig. 1). According to Halpert, carcinomas of the lung originate from these "reserve cells" by atypical proliferation.

These malignant growths may, therefore, be classified into 3 types, depending upon the embryological direction of growth: (1) the "reserve-cell" carcinoma, (2) cylindrical-cell carcinoma, and (3) squamous-cell carcinoma. This conception of the embryological development of carcinomas is graphically illustrated by the development of the cells of the bronchial mucosa from a primitive entodermal cell (Fig. 2). According to D'Aunoy, Pearson, and Halpert the "reserve-cell" carcinomas consist of round, elongated, or polygonal cells growing in solid masses and forming no particular structure. Characteristically they have a palisade arrangement of the peripheral cells (Fig. 3). The cylindrical cell carcinomas are composed of cuboidal or columnar cells forming tubular or acinar structures, or are mounted on delicate connective tissue stalks in a papillary arrangement (Fig. 4). The squamous cell carcinomas have a tendency toward keratinization or to pearl formation with central keratinization (Fig. 5). A given tumor is as differentiated as its most differentiated part. If one accepts Halpert's classification, it is evident that only the "reserve-cell" carcinoma might be radiosensitive. As these represent, according to D'Aunoy, Pearson, and Halpert, approximately one-third of all carcinomas of the lung, it is obvious that relatively few pulmonary neoplasms should, on a theoretical basis at least, be radiosensitive. This is corroborated by the poor results obtained from this form of therapy. According to Halpert the gross characteristics of pulmonary carcinoma are in no way dependent upon the microscopic structures, but depend upon rapidity of growth and secondary changes which occur in the tumor, such as hemorrhage and necrosis.

As regards the location of primary neoplasia of the lung, the right side is involved slightly more often than the left. In Fischer's series of 3,735 cases of pulmonary carcinoma, the right side was involved in 53 per cent and the left in 45 per cent. In 2 per cent the lesions were bilateral. It is of interest that in 46, in which localization was given, of the 79 collected cases in which total pneumonectomy was performed for pulmonary neoplasm, the right side was involved in 19, or 41.3 per cent, whereas the left was involved in 27 patients, or 58.6 per cent. In 784 of Fischer's cases, in which the location according to the bronchus was designated, the findings were as follows: The right main bronchus was involved in 142; the left main bronchus in 115; the right upper lobe bronchus in 148; the left upper lobe bronchus in 130; the right lower lobe bronchus in 129; the left lower lobe bronchus in 105, and the middle lobe in 15. Most pulmonary neoplasms are centrally located, i.e., of hilar origin. According to Boyd, 90 per cent of these neoplasms are in the region of the hilum. In Frissel and Knox's series the incidence of hilar carcinomas was not so high, only 49.7 per cent. Seventeen and eight tenths per cent involved the parenchyma and were of the nodular variety; 6.5 per cent were peripheral; 23.9 per cent were diffuse, and 2.1 per cent were bilateral miliary.

SYMPTOMATOLOGY

There are few or no symptoms in the early course of bronchial carcinoma. The symptoms vary considerably and depend entirely upon the

location and the extent of the lesion. Generally, the symptoms are not produced by the neoplasm itself, but are due to secondary changes resulting from its presence. The most constantly encountered symptoms are cough and thoracic discomfort. The latter may vary from a slight consciousness to actual pain within the thorax. In those cases in which ulceration occurs hemoptysis is a prominent manifestation. Whenever occlusion of the bronchus occurs atelectasis, with displacement of the mediastinum toward the affected side, and consequent infection produce marked symptoms. In the peripherally located tumors with extension to the pleura, evidences of pleurisy with effusion may be present. Symptoms which appear late are loss of weight and strength, dyspnea, and osteo-artropathy. Due to the circumferential growth the vascularity of the tumor in its central portion becomes impaired resulting in necrosis and abscess formation. Pulmonary abscess without an antecedent pneumonitis or foreign body aspiration should be considered of malignant origin until proved otherwise. Likewise an unexplained cough and hemoptysis in a patient past 40 years of age should be considered the result of carcinoma until this diagnosis is excluded. The physical findings in pulmonary malignancies are as protean as the symptoms and are dependent upon the location and extent of the lesion and secondary pulmonary changes which may be produced by it.

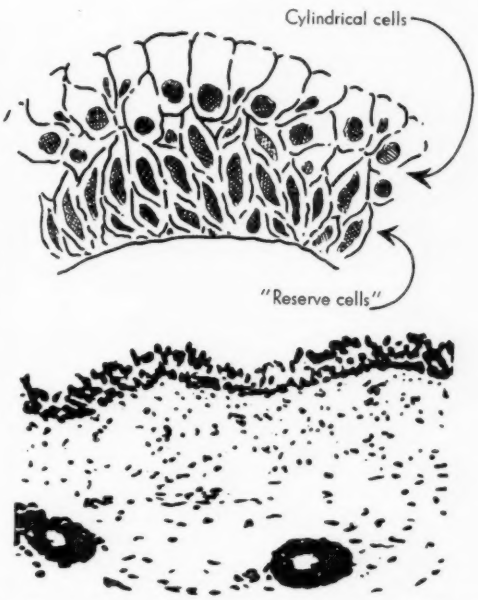


Fig. 1. Lining cells of tracheal mucosa of a fetus 12 centimeters long. Beneath the cylindrical cells covering the surface there are several rows of nuclei of "reserve cells." Modified after D'Aunoy, Pearson, and Halpert (13, 26).

DIAGNOSIS

The most important factor in the diagnosis of pulmonary carcinoma is the consideration of its possible presence. This lesion invariably should be suspected in every patient 40 years of age or older with unexplained cough, hemoptysis, or thoracic discomfort. While roentgenography, without the use of contrast media, is usually of little or no value in the *early* diagnosis of non-obstructive bronchial neoplasms, careful stereoroentgenographic studies are necessary in all such lesions. The roentgenographic interpretation of centrally located lesions is generally more difficult because of the confusion with hilar shadows produced by other lesions and normal structures. This is particularly significant because most pulmonary neoplasms occur in the hilar region. In centrally located lesions, after the condition has progressed to such an extent that bronchial obstruction occurs, atelectasis of one or more lobes develops, depending upon the degree of central location. The physical findings and particularly the roentgenographic manifestations of this condition are characteristic, i.e., dullness or shadow and displacement of the mediastinal structures toward the affected side (Fig. 6). In peripherally located pulmonary malignancy the roentgenographic diagnosis is dependent upon shadows produced by the infiltrating tumor (Fig. 7).

Of greatest importance, as regards accurate diagnosis, is bronchoscopic visualization of the tumor and biopsy obtained by this means. While the microscopic demonstration of malignancy of the bronchus is the ultimate ideal, there may be some difficulty in obtaining a satisfactory specimen. We are in complete accord with Jackson and Holinger that the incidence of correct diagnoses, made by bronchoscopic visualization of the lesion will probably be higher when made by one experienced in the bronchoscopic diagnosis of these tumors than by routine microscopic examination of biopsy specimens. This in part is due to the recalcitrance of most pathologists to diagnose carcinoma from the examination of a few cells; and it is also due to the fact that the inexperienced bronchoscopist may not obtain representative neoplastic tissue. In every instance, however, an attempt should be made to obtain tissue for microscopic examination, because, as

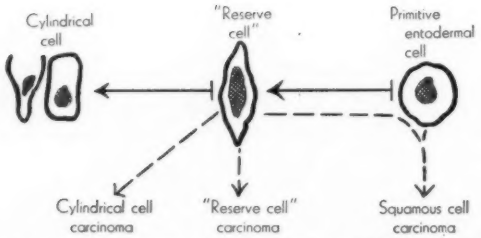


Fig. 2. The "reserve cell" is the parent cell of the ciliated cylindrical and goblet cells, and also possesses the qualities of its ancestor cell in that it may differentiate into any kind of epithelial cell that a primitive entodermal cell is capable of producing. Hence, the carcinomas of the lung may be: (1) "reserve-cell" carcinoma, (2) cylindrical-cell carcinoma, and (3) squamous-cell carcinoma. Modified after D'Aunoy, Pearson, and Halpert (13, 26).

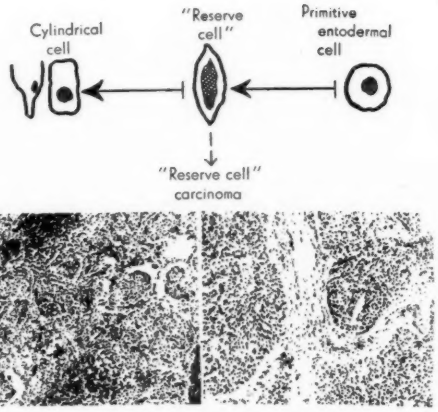


Fig. 3. "Reserve-cell" carcinomas grow in solid masses composed of round, elongated (oat cells) or polygonal cells forming no particular structure. Usually there is a palisade arrangement of the peripheral cells. Modified after D'Aunoy, Pearson, and Halpert (13, 26).

mentioned, this is the ideal method of diagnostic proof. According to Jackson and Konzelmann, the incidence of correct diagnoses obtained bronchoscopically is approximately 75 per cent. This is about the incidence of hilar tumors and indicates that those cases, which are close enough to the main stem bronchi to be visualized, can be diagnosed by the trained bronchoscopist. Difficulty is likely to be encountered in eparterial bronchus tumors because of their location and because of the acute angle which they form with the right stem bronchus. Visualization usually can be obtained in those cases, however, in which the neoplasm is near the orifice of the eparterial bronchus.

The presence of malignant cells in expectorated material can frequently be demonstrated microscopically. By this method of examination Dudgeon found carcinoma cells in 60 per cent of patients in whom a diagnosis of pulmonary neoplasm subsequently was proved. Similarly, the demonstration, according to Mandlebaum's technique of malignant cells in the pleural fluid of those cases in which there has been extension to the pleura, is of diagnostic importance. The latter is of little use early in the disease, however, because of the relatively late extension to the periphery, except in peripherally located lesions. The importance of this method of diagnosis lies principally in its prognostic value.

Thoracoscopic examination is another method of diagnosis in selected cases of pulmonary carcinoma and is particularly valuable in those cases with peripheral extension with or without pleural effusion. This method of examination is useful in determining the cause of the pleural effusion and the operability of the case. In those cases in which there is extensive seeding in the pleural cavity, an attempt at radical extirpation is obviously not justified. In cases in which the lesion is located peripherally, obviating bronchoscopic visualization of the tumor, aspiration biopsy can be performed with relative safety and with a fair degree of accuracy. Martin and Ellis, in 1930, reported their results in a large series of aspiration biopsies done for a variety of conditions. In 2 pulmonary carcinomas microscopic diagnoses of the lesions were positive. Sharp reports 3 cases in which a positive microscopic diagnosis of pulmonary neoplasm was made on material obtained by aspiration. He believes that the method is particularly valuable in upper lobe malignancies. Binkley reported 92 aspiration biopsies of the thorax performed in the Memorial Hospital. In 56 bronchogenic carcinomas a positive diagnosis was made by aspiration biopsy in 60 per cent, whereas bronchoscopic examination gave a positive diagnosis in only 43 per cent of this group. An accurate diagnosis is possible, following aspiration biopsy, only if the examining pathologist is capable of interpreting the changes occurring in the few cells obtained by this method, and if he is willing to commit himself on the basis of these findings.

TREATMENT

The treatment of carcinoma of the lung, as that of most carcinomas elsewhere, consists ideally of complete surgical extirpation. Surgical removal is particularly indicated in pulmonary malignancies, because of the almost hopeless outlook following other types of therapy. While in a number of

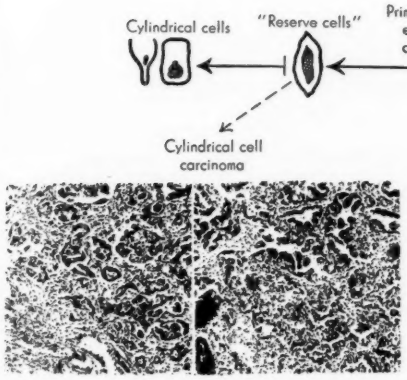


Fig. 4. Cylindrical cell carcinomas are composed of cuboidal or columnar cells forming acinar, tubular, or papillary structures. The parent cells are the "reserve cells" which form haphazard imitations of the normal epithelial cell structure which composes the air passages. Modified after the method of D'Aunoy, Pearson, and Halpert (13, 26).

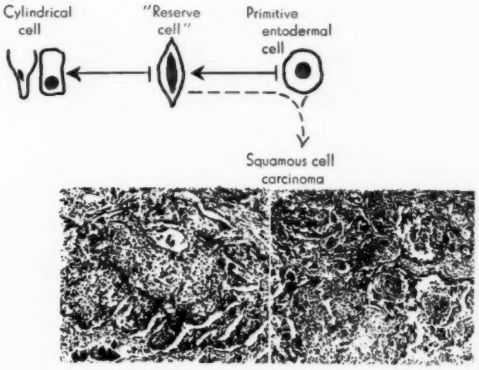


Fig. 5. Squamous cell carcinomas grow in nests of cells in a concentric arrangement forming epithelial pearls with central keratinization. The entodermal cell of the air passages has the quality of producing stratified squamous epithelium. The parent cell of this carcinoma is a "reserve cell" of earlier ancestry than the ordinary. Modified after D'Aunoy, Pearson, and Halpert (13, 26).

reported cases resections of the involved lobes have been performed, it seems to us that any procedure, short of total removal of the involved lung, is irrational. Only by complete excision of the entire lung can the primary focus be adequately removed, and lobectomy does not permit removal of the regional lymph nodes. The performance of simple lobectomy in carcinoma of the lung is just as illogical as partial removal of the breast in mammary carcinoma with no attempted extirpation of the regional lymph nodes. Another reason for total pneumonectomy is that approximately 75 per cent of pulmonary neoplasms originate in the proximal bronchi. As shown by Bonniot, Monod, and Evrard, it is not possible to apply a tourniquet high enough on the pedicle of the lung to permit division of the main bronchus without injuring the pericardium or other mediastinal structures. Moreover, from a technical standpoint, total pneumonectomy is a much more surgical and anatomical procedure than is lobectomy. The latter at best consists more or less of a makeshift operation. It is necessary almost invariably to cut through pulmonary tissue because of the incomplete division of the lung down to the hilum by the fissures which does not permit individual ligation of the bronchus and pulmonary vessels.

On the basis of our experience we are convinced that preliminary pneumothorax should be attempted in all cases of malignancies of the lung. This should be done preferably in stages, increasing the amount of intrapleural pressure gradually until the pressure is definitely upon the positive side. Most surgeons agree that a preliminary pneumothorax is desirable. The procedure was originally advocated by Kuemmel who performed the first pneumonectomy in November, 1910. Pre-operative pneumothorax is of diagnostic importance in determining the presence, extent, and location of adhesions, thus permitting the pre-operative planning of the operative procedure. In those cases in which extensive basal adhesions are present, a posterolateral approach is preferable to an anterior one, whereas, conversely, a patient with adhesions involving the apex can best be operated upon through an anterior approach. Another decided advantage of pre-operative pneumothorax is the gradual compression of the pulmonary capillary bed, giving the right heart a chance to compensate for the increased peripheral resistance in this area, rather than permitting a sudden cutting off of the blood to the involved lung at the time of the ligation of the pulmonary vessels. This is particularly true in elderly patients whose cardiac reserve is diminished, and in whom malignancies of the lung are likely to occur.

Rienhoff (46) advocates the pre-operative introduction of beef broth bouillon into the pleural cavity in order to produce a serofibrinous pleurisy, which he believes decreases the incidence of infection following the operation.

Patients with pulmonary carcinoma usually have an anemia because of the associated infection and loss of blood. In such instances pre-

operative unmodified blood transfusions are desirable. It is also imperative that two or more donors be available at the time of operation, because prolonged bleeding may follow division of extensive adhesions, and because of possible accidental massive hemorrhage in which the administration of blood during the operation is frequently life-saving.

Anesthesia. Although pneumonectomy may be performed under local and spinal analgesia, the latter being particularly popular in Canada and England, we prefer cyclopropane inhalation anesthesia. Because of the wide opening in the chest wall, it is necessary that the anesthetic be administered under positive pressure. All of our earlier cases were done under positive pressure, intratracheal tubes being used, but we now are convinced and agree with Rienhoff (46) that the use of the intratracheal tube is deleterious, because of the likelihood of the introduction of infection and the increased secretion resulting from trauma, which in the presence of a single lung following pneumonectomy, is particularly dangerous. One of our fatalities 14 hours after operation undoubtedly was due to trauma of the trachea by the intratracheal tube, resulting in such excessive secretion that the patient virtually drowned in her own secretions despite almost continuous aspiration (Case 5).

In those cases in which the pleural cavity is free, containing no adhesions, the anterior approach advocated by Rienhoff (47, 48) is very satisfactory. Instead of the intercostal incision suggested by Rienhoff, we are of the opinion that resection of the third rib from the lateral border of the sternum to the anterior axillary line is preferable (Figs. 8, 9). This gives a better exposure and permits a more satisfactory closure because it facilitates accurate approximation without tension of the pleura and intercostal muscles. The anterior approach is also applicable to those cases in which the lesion is located in the periphery of the upper lobe, and in which there are adhesions between the upper lobe and the parietal pleura. This approach, however, is not recommended for those patients in whom there are adhesions between the lower lobe and the posterior parietal pleura, because of the great difficulty encountered in mobilizing the lung. In such cases resection of the fifth rib through the incision suggested by Crafoord has been more satisfactory in our hands (Figs. 10, 11, 12).

A distinct advantage of the latter approach, in addition to permitting the division of adhesions between the lower lobe and the lateral and posterior parietal pleuras under direct vision, is that the hilum can be approached from behind, thus allowing initial mobilization of the relatively fixed bronchus. Following division of the bronchus, which normally holds the hilar structures quite rigidly, dissection of the other hilar structures, the pulmonary artery and veins, is greatly facilitated (Fig. 13). In the posterior approach also, rib resection is preferable to intercostal incision. After the pleural cavity is opened and the lung is mobilized by division of adhesions *by sharp dissection*, the hilum is exposed in the mediastinum by incising the mediastinal pleura anteriorly and superiorly in the anterior approach, and posteriorly and superiorly in the posterior approach (Fig. 14). The flap of mediastinal pleura thus formed is mobilized, thus exposing the hilar structures. The mobilization is greatly facilitated by the use of long, ball-tipped, slightly curved scissors (Fig. 14). The pulmonary artery, pulmonary veins, and bronchus are isolated individually (Fig. 15).

Mass ligation of the hilum is to be condemned as an unsurgical procedure and one which will give bad results in the majority of cases because of the incomplete extirpation. It does not permit removal of the mediastinal lymph nodes in which metastases are likely to occur, and in many instances does not permit the complete removal of the tumor. This is particularly exemplified in our first case in which the tumor was located just beyond the bifurcation of the trachea in the left main-stem bronchus. Although individual ligation of the hilar structures was performed, the bronchus was divided insufficiently high to include the tumor. The pathologist, who was present at the operation, noticed the absence of the tumor before the mediastinal wound was closed, permitting further dissection of the bronchus up to the carina and the high removal of the bronchus and the adjacent wall of the trachea (Fig. 16). The tumor was situated in the small segment of bronchus which was approximately 2 centimeters in length. The posterior approach is particularly applicable and desirable in those cases of right-sided malignancies because of the greater difficulty in approaching the hilum on this side due to the presence of the vena azygos extending over the eparterial bronchus. This is especially true in cases in which the lesion originates in the eparterial bronchus and in which extension to the mediastinum in this area is likely to be present. In 1 of our cases the inability to free the bronchus anteriorly necessitated ligation of the vena azygos. Subsequent slippage of the ligature resulted in fatal hemorrhage (Case 2). Through the posterior approach the vena azygos can be

Fig. 6. Anteroposterior roentgenogram of chest of patient with carconoma involving right lower lobe bronchus as characterized by slightly rounded but irregular shadow in lower right lung field adjacent to hilum. The mediastinum is displaced slightly toward the affected side (Case 3).

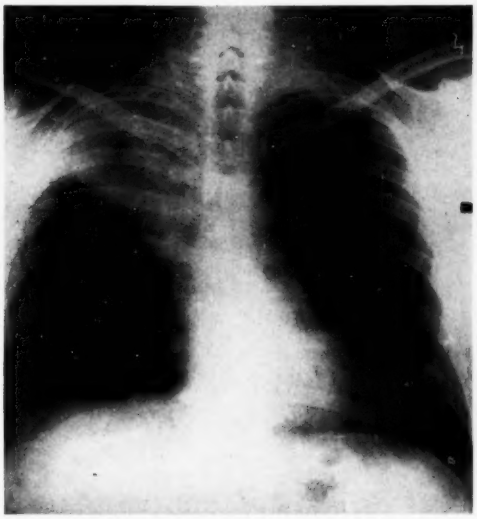


Fig. 7. Anteroposterior roentgenogram of chest of patient with carcinoma of right upper lobe bronchus which had extended peripherally to involve practically the entire lobe as confirmed by subsequent examination. The area of increased density, occupying nearly the whole upper lobe of the right lung, is produced by the peripheral extension of the tumor and not by atelectasis which would cause displacement of the mediastinum toward the affected side (Case 2).

more easily and more safely ligated before the bronchus is isolated (Fig. 13). Separate ligation of the pulmonary vessels is imperative, and is perfected by double transfixion sutures (Fig. 17). The use of No. 2 silk, which is sufficiently strong to compress the vessels and not too large to interfere with the tying of the knot, is considered preferable to other suture materials. The bronchus is doubly clamped by means of crushing forceps and divided between the clamps (Fig. 13). Before the bronchus is closed by means of interrupted No. 1 silk sutures, approximating the mucosal edges, the distal cartilaginous ring is removed from the end of the bronchus. The removal of all the mediastinal lymph nodes is an essential part of the operation and can be accomplished either through the anterior or the posterior approach. Obviously mass ligation of the hilar structures will not permit this.

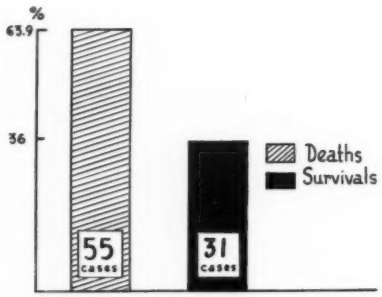
Following the complete extirpation of all the mediastinal lymph nodes careful pleuralization of the mediastinum is imperative. The edges of the divided mediastinal pleura are approximated, and the stump of the ligated vessels and bronchus is covered with pleura (Fig. 18). This is important to minimize the danger of infection and augment prompt healing of the bronchial stump.

In our cases we have not resorted to drainage, because we believe with Rienhoff (49) that filling of the pleural cavity with fibrinous exudate is important in the obliteration of the cavity. Obliteration of the cavity also is facilitated by elevation of the diaphragm which follows crushing of the phrenic nerve at the beginning of the operation. The thoracic wound is tightly closed, using interrupted No. 1 silk sutures for the pleura and the intercostal muscles. The superficial muscles and the skin are closely approximated by means of the same material. A compression sea sponge bandage is applied over the wound to obliterate the dead space and to lend support to the wound.

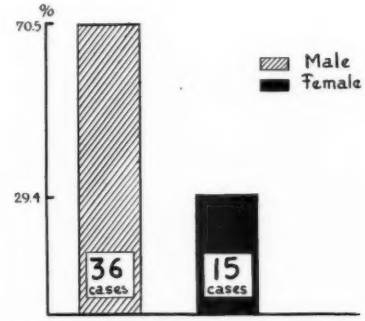
ANALYSES OF CASES

There have been 79 reported cases of total pneumonectomy for neoplastic disease. In addition to this number, the authors have performed total pneumonectomy for malignant disease of the lung in 7 cases making a total of 86 cases[1] (Table I, Graph 1). Of the 86 collected cases, including those of the authors, 55 (63.9 per cent) died and 31 (36 per cent) recovered. Of the 31

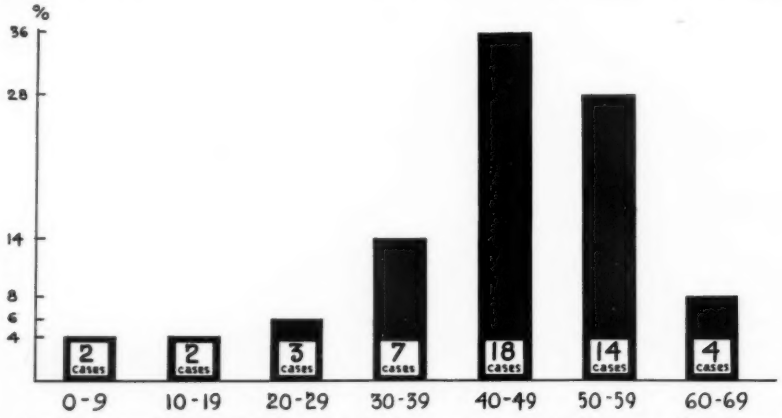
[1] Since this presentation 2 more patients have been operated upon. One, a male, age 56 years, had carcinoma of lower left bronchus. Pneumonectomy of left lung was performed November 17, 1938. Patient made uneventful recovery. The second patient was a white female with a metastatic melanoma of left main stem bronchus having its origin from a melanoma of right eye removed 23 years previously. Pneumonectomy of left ung was done October 12, 1938. Patient died 12 days after operation of uremia. Thus of total series of 9 cases 3 have recovered and 6 have died, giving a total mortality of 66 per cent.



Graph 1. Graphic representation of total mortality in 86 collected cases of pneumonectomy for neoplastic disease, including 7 performed by the authors



Graph 3. Graphic representation of sex incidence in 51 collected cases of pneumonectomy including authors'.

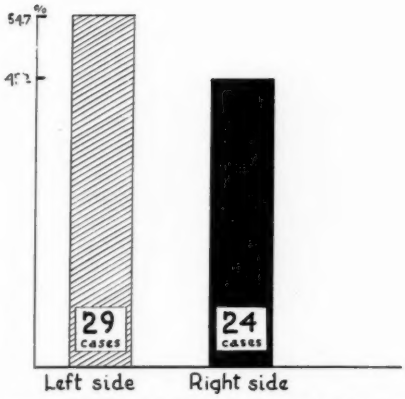


Graph 2. Graphic representation of age incidence according to decades in 50 collected cases of pneumonectomy including authors'.

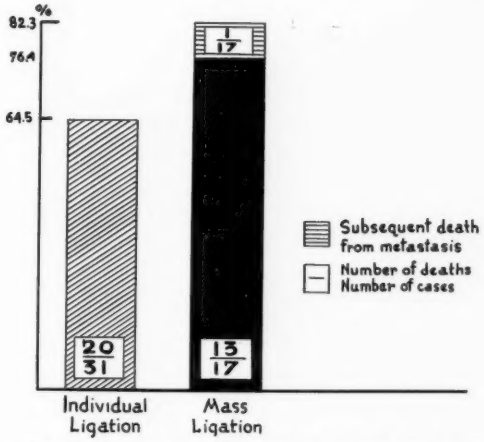
patients who recovered there were 5, or 5.8 per cent of the entire group of 86, who subsequently died either of metastases or of other causes. In 50 the age of the patient was stated. Two (4 per cent) were in the first decade of life, the younger being 3½ years of age with a lymphosarcoma; 2 (4 per cent) in the second decade; 3 (6 per cent) in the third decade; 7 (14 per cent) in the fourth decade; 18 (36 per cent) were in the fifth decade; 14 (28 per cent) in the sixth decade; and 4 (8 per cent) in the seventh decade (Graph 2). Of the 50, 32 (64 per cent) occurred in the fifth and sixth decades. Of significance also is the fact that 14 (28 per cent) were younger than forty years of age.

The sex was stated in 51 cases, including the authors' cases, of which 36 (70.5 per cent) were males and 15 (29.4 per cent) were females (Graph 3).

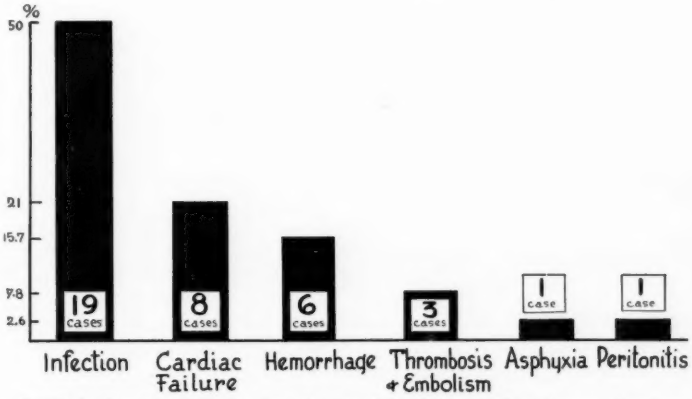
The localization as regards the side involved was stated in 53 cases. The left side was involved in 29 (54.7 per cent) and the right in 24 (45.2 per cent) (Graph 4). In 31 cases, including all of the authors', individual ligation of the hilar structures was done. Of this group, 11 (35.4 per cent) recovered, and 20 (64.5 per cent) died. Of 17 cases in which mass ligation was done and so stated, 4 (23.5 per cent) recovered and 13 (76.4 per cent) died. If we included in the fatal group having mass ligation 1 of the patients recovering, who subsequently died of metastases, and in whom death may have been the result of incomplete removal of the lung, these respective figures would be 17.6 per cent and 82.3 per cent (Graph 5). This difference in the mortality percentage in the two techniques of treatment of the hilar structures demonstrates the superiority of individual ligation of the bronchus and pulmonary vessels combined with extirpation of the mediastinal lymph nodes.



Graph 4. Graphic representation of localization, according to side involved, of pulmonary neoplasms in 53 collected cases of pneumonectomy including authors'.



Graph 5. Graphic representation of mortality in 48 collected cases of pneumonectomy including authors', according to treatment of hilar structures.

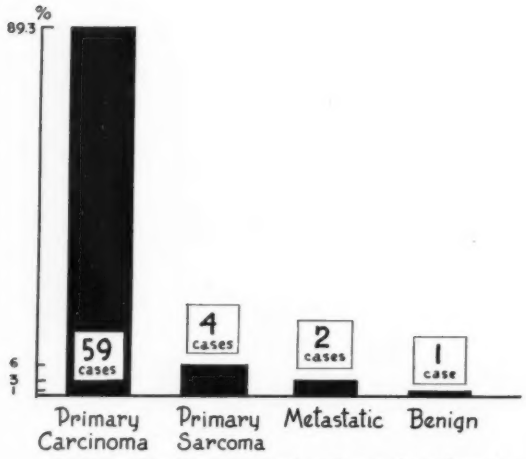


Graph 6. Graphic representation of cause of death in 38 collected cases of pneumonectomy including authors'.

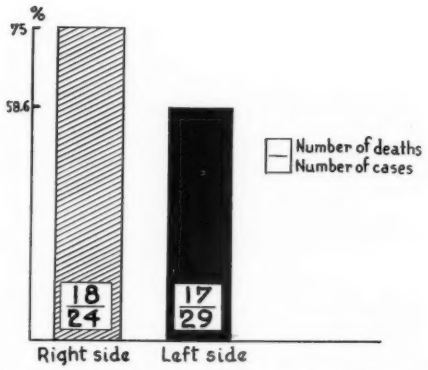
In 38 collected cases, including the authors' series, death as a result of the operation was due to the following: 6 (15.7 per cent) hemorrhage; 8 (21 per cent) cardiac failure; 19 (50 per cent) infection; 2 (5.2 per cent of the total) late hemorrhage as a result of the infection; 3 (7.8 per cent) thrombosis and embolism; 1 (2.6 per cent) asphyxia; and 1 (2.6 per cent) peritonitis (Graph 6).

The type of neoplasm was stated in 66 cases including the authors'. Fifty-nine (89.3 per cent) were carcinoma; 4 (6 per cent) were primary sarcoma; 2 (3 per cent) were metastatic lesions, (1, a metastatic sarcoma from a primary focus in the uterus, and 1, a melanoma in which the primary lesion had previously been removed. It was the surgeon's opinion in the latter case that the lung extirpation had resulted in recovery). In 1 (1.5 per cent) the lesion was found to be benign (Graph 7).

It has been the authors' experience that a total pneumonectomy on the right side is technically more difficult than that on the left, due principally to the fact that on the right side the vena azygos crosses over the eparterial bronchus, usually making the mobilization of the right main-



Graph 7. Graphic representation of type of neoplasm in 66 collected cases of pneumonectomy including authors'.



Graph 8. Graphic representation of mortality in 53 collected cases of pneumonectomy including authors', according to side of operation.

stem bronchus difficult. This is borne out by the results obtained in right and left-sided lesions in the collected cases including the authors'. Of 24 patients with right-sided lesions, 6 (25 per cent) recovered, and 18 (75 per cent) died. Of 29 patients who were afflicted with left-sided lesions, 12 (41.3 per cent) recovered and 17 (58.6 per cent) died (Graph 8).

Of the authors' 7 cases, 5 died and 2 recovered, giving a mortality rate of 71.4 per cent and a recovery incidence of 28.5 per cent. Of the 5 fatal cases, 1 died on the table of hemorrhage as a result of slippage of the ligature from the vena azygos shortly after it was applied. In this case there was infiltration of the mediastinum in the region of the vena azygos, the tumor extending from the eparterial bronchus (Case 2). One died of asphyxia about an hour after the completion of the operation, because of the tongue dropping back before the patient had sufficiently recovered from the anesthetic (Case 4). One patient died as a result of severe tracheitis and pulmonary edema in the opposite lung which, in the authors' opinion, was the result of trauma to the trachea by the intratracheal tube (Case 5). One died of cardiac failure 5 days after the operation. Pre-operatively

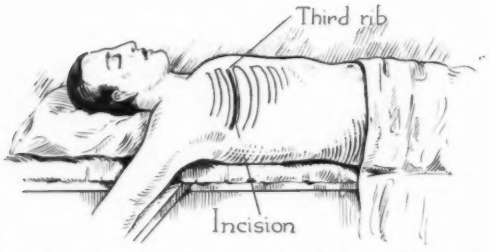


Fig. 8. Drawing illustrating site of skin incision over third rib from chondrosternal junction to anterior axillary line in anterior approach for pneumonectomy.

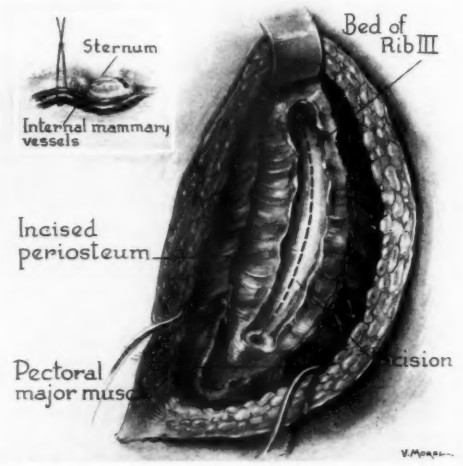


Fig. 9. Drawing illustrating anterior approach for pneumonectomy. The third rib is resected subperiosteally from chondrosternal junction to anterior axillary line. Incision of the pleura is made in the bed of the third rib. Inset shows exposure and immediate ligation of internal mammary vessels.

Fig. 10. Drawing showing position of patient in posterior approach for pneumonectomy.

there was electrocardiographic evidence of considerable myocardial damage. During the first 4 postoperative days his convalescence was very satisfactory. On the fifth day the pulse became irregular but slow, and about 10 hours after this developed the patient died. Postmortem examination revealed no other cause of death, except myocarditis (Case 6). One patient died of peritonitis from rupture of the intestine as a result of gangrene complicating a periarteritis nodosa of the mesenteric vessels 10 days after operation. The pulmonary wound was well healed, and there was no evidence of any disturbance in the chest (Case 3). One patient is living 2½ years after operation (Case 1). The remaining patient survived the operation but the operation was done so recently that it is too soon to draw any conclusions concerning the outcome (Case 7).

Fig. 12. Drawing showing method of elevating angle of scapula so as to expose the fifth rib along its entire length. The fifth rib is subperiosteally resected throughout its entire length and the pleura is opened by incising in the furrow left by the rib.

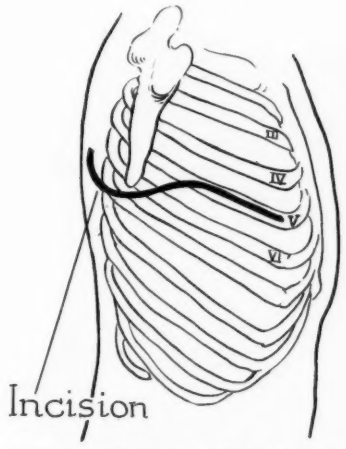


Fig. 11. Drawing illustrating skin incision in posterior approach for penumonectomy as devised by Crafoord. The incision begins over the fourth rib about 7 to 8 centimeters from the posterior midline, is extended downward beneath the angle of the scapula, and then up toward the midaxillary line to the level of the fifth rib which is followed anteriorly to the costal cartilage.

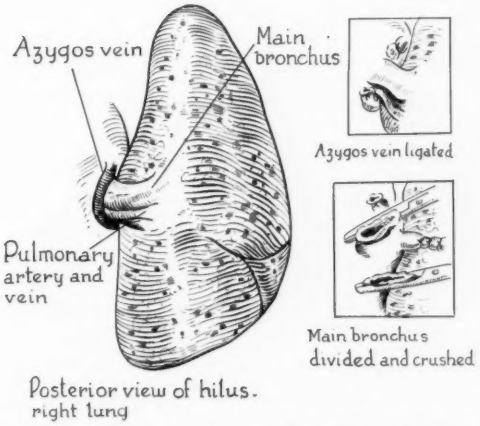


Fig. 13. Drawing showing relation of hilar structures and steps of operation in posterior approach for pneumonectomy. The hilar structures are exposed by incising mediastinal pleura posteriorly and superiorly. The azygos vein is first exposed, doubly transfixed and ligated, and then divided between these ligatures. This permits easy access to the bronchus which is doubly clamped by means of crushing forceps and divided between the clamps. Following division of bronchus, which normally holds the hilar structures quite rigidly, dissection of the other hilar structures, the pulmonary artery and veins, is greatly facilitated.

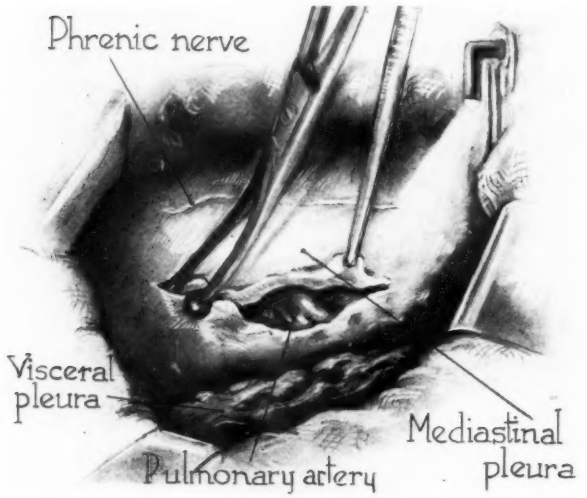


Fig. 14. Drawing showing incision of mediastinal pleura in anterior approach for pneumonectomy. Mobilization of flaps of mediastinal pleura is greatly facilitated by use of long ball-tipped, slightly curved scissors.

SUMMARY

1. Primary pulmonary carcinoma is an important clinical entity because of its frequent occurrence. It occurs in approximately 1 to 2 per cent of all autopsies and from 10 to 15 per cent of all carcinomas.

2. Chronic irritation of the bronchial mucosa is probably the most important etiological factor. Repeated inhalation of smoke over long periods of time is believed to be a prominent, irritative factor.

3. All pulmonary carcinomas probably originate in the bronchial mucosa. A classification based upon the embryological derivation of the tumor cell is presented.

4. Persistent cough with expectoration and hemoptysis, and thoracic discomfort are the most prominent symptoms and when present in a person past 40 years of age should always be considered as due to pulmonary neoplasm until proved otherwise.

5. Roentgenographic examination is particularly valuable in peripherally located lesions with parenchymal infiltration and in centrally located lesions with bronchial obstruction. Because most bronchial malignancies occur in the primary bronchi, bronchoscopy is especially valuable as a diagnostic procedure.

6. Treatment of pulmonary malignancy consists of total extirpation of the involved lung and removal of the mediastinal lymph nodes. Lobectomy and mass ligation of the hilar structures are condemned because they do not permit complete eradication of the lesion. Preliminary pneumothorax always should be attempted. Depending upon the location of the lesion, the presence and extent of adhesions, either the anterior or posterior approach with rib resection should be used in the treatment of these patients.

7. An analysis of 79 collected and 7 personal cases of total pneumonectomy for neoplastic disease is presented.

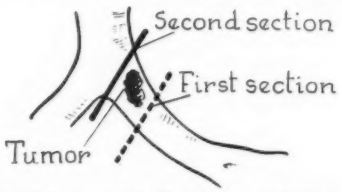


Fig. 16. Diagrammatic illustration of futility of mass ligation and necessity of high section of bronchus as exemplified in authors' first case. Although individual ligation of hilar structures was done, the bronchus was divided insufficiently high to include the tumor. The pathologist, who was present at the operation, observed absence of tumor before mediastinal wound was closed, permitting further dissection of bronchus up to carina and high removal of bronchus to include tumor.

Fig. 15. Drawing showing individual isolation of pulmonary artery, pulmonary vein, and bronchus in anterior approach for pneumonectomy.

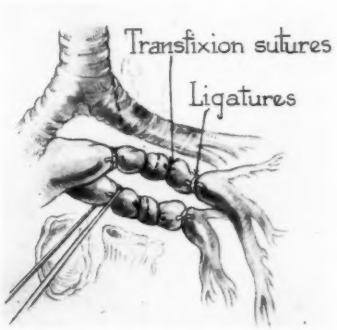


Fig. 17. Diagrammatic illustration of technique which is employed in individual isolation of hilar structures. Division of the pulmonary artery and of the pulmonary veins is performed between double ligation and transfixion sutures.

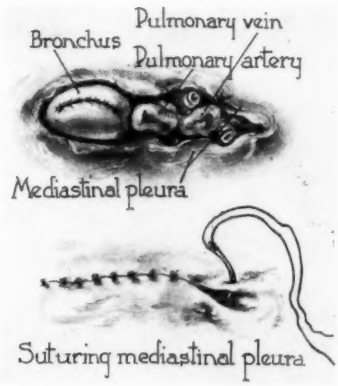


Fig. 18. Drawing showing pleuralization of mediastinum following complete extirpation of all mediastinal lymph nodes. The edges of the divided mediastinal pleura are approximated covering the stump of the ligated vessels and bronchus with pleura.

TABLE I.—SUMMARY OF REPORTED AND AUTHORS' CASES OF PNEUMONECTOMY FOR PULMONARY NEOPLASMS

Author and ref.	Date of operation	Date reported	Lesion	Age	Location					Sex	Ligation	R′	D	Length of life	Cause of death
					R	L	U	L′	M						
Kuemmel (34)	11–15–10	1911	Carcinoma*‡	48	+					M	Mass		+	6 days	Bronchitis opp. lung, metastasis to pleura at time of operation
Meyer (42)	4–26–20	1923	Lymphosarcoma	5½	+					M	Mass		+	10 hrs.	Edema of left lung
Hinz (27)	11– 8–22	1923	Carcinoma	56		+		+		F	Individual		+	60 hrs.	Emphysema of mediastinum and other lung
Archibald (5)	12– 2–31 2–12–32 (2 stages)	1934	Carcinoma†	34		+				M	Mass		+	4 days	Streptococcic septicemia and pulmonary edema
Archibald (5)	7– 7–33	1934	Sarcoma ‡	31		+	+			M	Mass	+		8 mos.	Metastasis
Bigger (6)	3– 8–32 3–11–32 (2 stages)	1935	Carcinoma†	14		+				M	Individual		+	41 days	Pericarditis; bronchopneumonia
Ivanissevich and Ferrari (30)	10–11–32	1933	Carcinoma	45		+	+			M	Individual		+	8 days	Cardiac failure; pulmonary edema
Lilienthal (37)	1–28–33	1933	Metastatic sarcoma from uterus	34		+		+		F	Mass		+	4 days	Bronchopneumonia opp. lung
Graham and Singer (23)	4– 5–33	1933	Carcinoma	48		+		+		M	Mass	+			
Graham (24)		1936	Carcinoma										+	3½ wks.	Pneumonia
Graham (24)		1936	Carcinoma										+	3 wks.	Pneumonia
Graham (24)		1936	Carcinoma										+		Cerebral metastasis
Rienhoff (47)	7–24–33	1933	Sarcoma	3½		+				F	Individual	+			
Rienhoff (47)	11– 3–33	1933	Benign tumor	24		+				F	Individual	+			
Rienhoff (48)		1936										+ (?)			
Rienhoff (48)		1936										+ (?)			
Rienhoff (48)		1936										+ (?)			
Rienhoff (48)		1936											+	5 days	
Rienhoff (48)		1936											+	6 wks.	
Rienhoff (48)		1936											+	6 mos.	Metastasis
Freedlander (20) (Case 1)	11– 4–33	1937	Carcinoma	44		+		+		M	Mass		+	11 days	Empyema; bronchopneumonia
Freedlander (20) (Case 2)	9–26–34	1937	Carcinoma	45	+			+		M	Mass		+	1 mo.	Empyema; metastasis
Freedlander (20) (Case 4)	8–19–36	1937	Carcinoma	40	+			+		F	Individual	+			
Freedlander (20) (Case 5)	11– 9–36	1937	Carcinoma	47		+	+			M	Individual		+	11 days	Pulmonary edema; empyema; mediastinitis; pericarditis
Freedlander (20) (Case 7)	3– 6–37	1937	Carcinoma	39	+			+		M	Individual		+	18 days	Empyema; hemorrhage anterior pulmonary vein
Overholt (43) (Same as Case 1 in Ref. 44)	11–13–33	1934	Carcinoma	33	+				+	F	Mass	+			

Key: R—right lobe; L—left lobe; U—upper lobe; L′—lower lobe; M—middle lobe; R′—recovered; D—died.
*Indicates involvement of entire lung.
†Indicates involvement of hilar region.
‡The patients died subsequently of metastases or other causes.

TABLE I.—SUMMARY OF REPORTED AND AUTHORS' CASES OF PNEUMONECTOMY FOR PULMONARY NEOPLASMS—Continued

Author and ref.	Date of operation	Date reported	Lesion	Age	Location					Sex	Ligation	R′	D	Length of life	Cause of death
					R	L	U	L′	M						
Overholt (44) (Case 2)	5- 2-34	1935	Carcinoma	42		+		+		F	Mass	+			
Overholt (44) (Case 3)	7- 7-34	1935	Carcinoma†	43		+				M	Mass		+	48 hrs.	Severe pulmonary hemorrhage
Overholt (44) (Case 5)	11-13-34	1935	Carcinoma†	37		+				M	Mass		+	Operation	Hemorrhage
Overholt (44) (Case 6)	12- 8-34	1935	Carcinoma	50	+				+	M	Mass		+	6 days	Pneumonia
Overholt (44) (Case 8)	4- 8-35	1935	Carcinoma	59		+	+			F	Individual	+			
Overholt (45)		1938	Carcinoma										+		
Overholt (45)		1938	Carcinoma									+			
Overholt (45)		1938	Carcinoma									+			
Overholt (45)		1938	Carcinoma									+			
Overholt (45)		1938	Carcinoma									+			
Edwards (16)		1934	Carcinoma		+					M	Mass		+	16 days	Empyema; pericarditis; bronchial fistula
Edwards (16)		1934	Carcinoma		+						Mass		+	3 days	Cardiac failure
Edwards (17)												+			
Edwards (17)												+			
Edwards (17)												+			
Edwards (17)													+		
Alexander (1)	11- 6-33	1935 1936	Carcinoma			+							+	30 days	Cardiac failure
Flick and Gibbon (19)	6-13-34	1936	Carcinoma	46		+	+			M	Individual		+	2 mos.	Metastasis
Duval and Monad (15)	2-14-35	1935	Carcinoma	59	+			+		M			+	Operation	Mediastinal metastasis to rt. auricle
Lyle (38)	2-20-35	1936	Carcinoma	61	+			+		F	Individual	+			
Lambret (35)	3-19-35	1935	Carcinoma	59		+	+			M	Individual		+	18 hrs.	Shock and hemorrhage
Santy et al (50) (Case 2)	10- 7-35	1936	Carcinoma	45		+	+			M	Mass		+	8 days	Pulmonary congestion
Frissel and Knox (21)	2-20-35	1937	Carcinoma‡	64	+					M		+		6 mos.	
Haight (25)		1935	Carcinoma			+						+			
Arce (3)		1936	Carcinoma										+	8 hrs.	
Arce (3)		1936	Carcinoma										+	48 hrs.	Thrombus rt. heart
Arce (3)	9-15-36	1936	Metastatic melanoma	27		+		+		F		+			
Arce (4)		1938									Tamponade		+		
Arce (4)		1938									Tamponade		+		
Arce (4)		1938									Tamponade		+		
Arce (4)		1938									Tamponade		+		
Arce (4)		1938									Tamponade		+		
Arce (4)		1938									Tamponade		+		
Churchill (10)		1935										+			

Key: R—right lobe; L—left lobe; U—upper lobe; L′—lower lobe; M—middle lobe; R′—recovered; D—died.
*Indicates involvement of entire lung.
†Indicates involvement of hilar region.
‡The patients died subsequently of metastases or other causes.

TABLE I.—SUMMARY OF REPORTED AND AUTHORS' CASES OF PNEUMONECTOMY FOR PULMONARY NEOPLASMS—Concluded

Author and ref.	Date of operation	Date reported	Lesion	Age	Location					Sex	Ligation	R′	D	Length of life	Cause of death
					R	L	U	L′	M						
Churchill (11)		1937	‡									+			Metastasis
Churchill (11)		1937	‡									+			Metastasis
Churchill (11)		1937											+		
Churchill (11)		1937											+		
Churchill (11)		1937											+		
Holst (29)		1937	Carcinoma	52						F			+	8 days	Empyema
Crafoord (Case 1) (12)	7- 9-34	1938	Carcinoma	26	+			+		F	Individual		+	Day of operation	Hemorrhage into pleural cavity
Crafoord (Case 2) (12)	9-16-35	1938	Carcinoma	45		+	+			M	Individual		+	7 wks.	Lung abscess—opposite lung, requiring drainage
Crafoord (Case 3) (12)	3-16-36	1938	Carcinoma	52	+			+		M	Individual		+	1 day	Thrombosis and embolism of carotid artery
Crafoord (Case 4) (12)	4-21-36	1938	Carcinoma†	46		+				M	Individual	+			
Crafoord (Case 5) (12)	6-16-36	1938	Carcinoma	44	+		+			M	Individual		+	6 days	Empyema and mediastinitis
Crafoord (Case 6) (12)	9- 3-36	1938	Carcinoma	50	+			+		M	Individual		+	3 days	Thrombosis and embolism of pulmonary artery
Crafoord (Case 7) (12)	8-12-37	1938	Carcinoma	47		+		+		F	Individual		+	11 days	Alectasis and pulmonary edema
Crafoord (Case 8) (12)	8-16-37	1938	Carcinoma‡	50		+		+		M	Individual	+		5 mos.	Cardiac failure; pneumonia
Crafoord (Case 9) (12)	9-23-37	1938	Carcinoma	63		+	+			M	Individual		+	36 hrs.	Pulmonary edema
Crafoord (Case 10) (12)	11-24-37	1938	Carcinoma	50	+			+		M	Individual	+			
Crafoord (Case 11) (12)	2-28-38	1938	Carcinoma	50		+		+		M	Individual	+			
Crafoord (Case 12) (12)	3- 2-38	1938	Carcinoma	50	+			+		M	Individual		+	3 days	Atelectasis and bronchitis
Matson et al (41)	3- 5-36	1938	Carcinoma	36	+		+			M	Mass		+	26 days	Empyema; bronchial fistula; hemorrhage from superior pulmonary vein
Ochsner and DeBakey (Case 1—W.R.)	4-15-36		Fibrosarcoma†	19		+				M	Individual	+			
Ochsner and DeBakey (Case 2—H.D.R.)	6-23-37 6-26-37 (2 stages)		Carcinoma	42	+		+			M	Individual		+	Operation	Hemorrhage from azygos vein
Ochsner and DeBakey (Case 3—R.J.)	7-28-37		Carcinoma	40	+				+	F	Individual		+	10 days	Peritonitis; perforation of intestine; periarteritis nodosa
Ochsner and DeBakey (Case 4—F.P.)	4-26-38		Carcinoma	62	+		+			M	Individual		+	1 hr.	Asphyxia
Ochsner and DeBakey (Case 5—S.B.)	8-23-38		Carcinoma	45	+			+		F	Individual		+	14 hrs.	Pulmonary edema
Ochsner and DeBakey (Case 6—F.F.)	9-20-38		Carcinoma	52		+	+			M	Individual		+	5 days	Cardiac failure
Ochsner and DeBakey[1] (Case 7—A.I.)	10- 6-38		Carcinoma	58	+			+		M	Individual	+			

Key: R—right lobe; L—left lobe; U—upper lobe; L′—lower lobe; M—middle lobe; R′—recovered; D—died.
*Indicates involvement of entire lung.
†Indicates involvement of hilar region. ‡The patients died subsequently of metastases or other causes.
[1]See footnote under Analysis of Cases.

REFERENCES

1. ALEXANDER, J. Personal communication to Haight. Surg., Gynec. & Obst., 1934, 58: 768.
2. Idem. Observations on total pulmonary lobectomy and pneumonectomy. Ann. Surg., 1935, 101: 393.
3. ARCE, M. J. Pneumectomie totale (Le tampon-drainage en chirurgie endothoracique). Mém. Acad. de Chir., 1936, 62: 1412.
4. Idem. Tratamiento quirurgico de los quiste y tumores del pulmón (metodos y procedemuntos generales). Soc. Internat. de Chir., 11th Congress, Sept., 1938.
5. ARCHIBALD, E. The technique of total unilateral pneumonectomy. Ann. Surg., 1934, 100: 796.
6. BIGGER, I. A. The diagnosis and treatment of primary carcinoma of the lung. South. Surg., 1935, 4: 401.
7. BINKLEY, J. S. Aspiration biopsy of lung. Presented at 21st annual meeting of the Am. Soc. Thoracic Surg., 1938 (in press)—J. Thoracic Surg. Reviewed by I. A. Bigger, Surgery, 1938, 4: 307.
8. BONNIOT, MONOD, O., and EVRARD, H. Considérations anatomiques pour servir à l'abord des pédicules pulmonaires par voie antérieure. J. de chir., 1936, 48: 173.
9. BOYD, W. Pathology of primary carcinoma of the lung. Canadian M. Ass. J., 1930, 23: 210.
10. CHURCHILL, E. D. Discussion of Overholt's paper. J. Thoracic Surg., 1935–36, 5: 80.
11. Ibid. Lobectomy and pneumonectomy in bronchiectasis and cystic disease. 1936–37, 6: 286.
12. CRAFOORD, C. On the Technique of Pneumonectomy in Man. Stockholm: Tryckiri Aktiebolaget Thule, 1938.
13. D'AUNOY, R., PEARSON, B., and HALPERT, B. Personal communications.
14. DUDGEON, L. S., and WRIGLEY, C. H. On demonstration of particles of malignant growth in sputum by means of wet-film method. J. Laryngol. & Otol., 1935, 50: 752.
15. DUVAL, P., and MONAD, R. Discussion of Lambret's paper: Pneumectomie totale pour cancer du poumon gauche. Bull. et mém. Soc. nat. de chir., 1935, 61: 813.
16. EDWARDS, A. T. Malignant diseases of the lung. J. Thoracic Surg., 1934–35, 4: 107.
17. Idem. Quoted by Crafoord, Ref. No. 12.
18. FISCHER, W. In Henke and Lubarsch: Handbuch der speziellen pathologischen Anatomie und Histologie. Berlin: Springer, 1931, 3, 3: 509.
19. FLICK, J. B., and GIBBON, J. H., JR. Total removal of the left lung for carcinoma. Ann. Surg., 1936, 103: 130.
20. FREEDLANDER, S. O. Total pneumonectomy. Ohio State M. J., Columbus, 1937, 33: 769.
21. FRISSEL, L. E., and KNOX, J. C. Primary cancer of the lung. Am. J. Cancer, 1937, 30: 219.
22. GOLDMAN, ALFRED. Cytology of serous effusions, with special reference to tumor cells. Arch. Surg., 1929, 19: 1672.
23. GRAHAM, E. A., and SINGER, J. J. Successful removal of an entire lung for carcinoma of bronchus. J. Am. M. Ass., 1933, 101: 1371.
24. GRAHAM, E. A. Primary carcinoma of the lung or bronchus. Ann. Surg., 1936, 103: 1.
25. HAIGHT, C. From discussion on "Pneumonectomy for malignant and suppurative disease of the lung," by R. Overholt. J. Thoracic Surg., 1935–36, 5: 77.
26. HALPERT, B. Pathology of bronchogenic carcinoma. N. Orleans M. & S. J. (in press).
27. HINZ, R. Totale extirpation der lunken hunge Wegen bronchial Carcinom. Arch. f. klin. Chir., 1923, 124: 104.
28. HOLINGER, P. Personal communication.
29. HOLST, J. Lobektomi og pulmeklomi ved bronchiektosi. Förhandl. ved nord. Kirurg. Forenings moote, 1937, 411: 415.
30. IVANISSEVICH, O., and FERRARI, R. C. La pneumectomia en el hombre. Bol. y trab. Soc. de cirug. de Buenos Aires, July 5, 1933, 17.
31. JACKSON, C. W. C., and KONZELMANN, F. W. Bronchial carcinoma; bronchus biopsy in a series of 32 cases. J. Thoracic Surg., 1935–36, 4: 165.
32. JAFFÉ, R. H. Primary carcinoma of lung. J. Lab. & Clin. Med., 1935, 20: 1227.
33. JUNGHANNS, H. Der Krebs der lunger bronchien und oberen luftwege. Ztschr. f. Krebsforsch., 1929, 28: 573.
34. KUEMMEL, H. Discussion of W. Mueller: Demonstration zur extirpation ganzer Lungenlappen. Verhandl. d. deutsch. Gesellsch. f. Chir., 1911, 40: 147.
35. LAMBRET, M. O. Pneumectomie totale pour cancer du poumon gauche. Bull. et mém. Soc. nat. de chir., 1935, 61: 804.
36. LANFORD, J. A. Personal communication.
37. LILIENTHAL, H. Pneumonectomy for sarcoma of the lung in a tuberculous patient. J. Thoracic Surg., 1932–33, 2: 600.
38. LYLE, H. H. M. Carcinoma of the right lung: Pneumectomy in one stage. Ann. Surg., 1936, 103: 124.
39. MANDLEBAUM, F. S. Quoted by Goldman, Ref. No. 22.
40. MARTIN, H. E., and ELLIS, E. B. Biopsy by needle puncture and aspiration. Ann. Surg., 1930, 92: 169.
41. MATSON, R. C., ROBERTS, J. M., and BISAILLON, M. Total removal of the right lung for bronchogenic carcinoma. Dis. of the Chest, 1938, 4: 43.
42. MEYER, W. Observations in lung suppuration and its treatment. Arch. Surg., 1923, 6: 361.
43. OVERHOLT, R. H. The total removal of right lung for carcinoma—report of a successful case. J. Thoracic Surg., 1934–35, 4: 196.
44. Ibid. Pneumonectomy for malignant and suppurative diseases of the lung. J. Thoracic Surg., 1935–36, 5: 54.
45. Idem. Clinical studies and treatment of primary carcinoma of the lung. J. Connecticut Med. Soc., 2: 122, 1938.
46. RIENHOFF, W. F., JR. The treatment of carcinoma of the lung. Surg. Clin. N. America, 1936, 16: 1459.
47. Idem. Pneumonectomy. A preliminary report on the operative technic in two successful cases. Bull. Johns Hopkins Hosp., Balt., 1933, 53: 390.
48. Idem. The surgical technic of total pneumonectomy. Arch. Surg., 1936, 32: 218.
49. Idem. Intrathoracic anatomical readjustments following complete ablation of one lung. J. Thoracic Surg., 1937, 6: 254.
50. SANTY, BONNIOT, DARGENT, CORAJOD, and BERARD. Lobectomie et pneumonectomie pour neoplasmes bronchopulmonaires. Lyon méd., 1936, 157:485 and 521.
51. SEYFARTH, C. Lungenkarzionon in Leipzig. Deutsche Med. Wchnschr., 1924, 50: 1497.
52. SHARP, G. The diagnosis of primary carcinoma of the lung by aspiration. Am. J. Cancer, 1931, 15: 853.
53. WINTERNITZ, M. A., WASON, I. M., and MCNAMARA, F. P. The Pathology of Influenza. New Haven: Yale University Press, 1920.

EVALUATION OF OVARIAN STERILIZATION FOR BREAST CANCER

GRANTLEY WALDER TAYLOR, M.D., F.A.C.S., Boston, Massachusetts

IN June, 1935, Dresser reported our experience at the Collis P. Huntington Memorial and Pondville State Hospitals with ovarian radiation in cases of carcinoma of the breast with bone metastases. Following the policies he reported, we have continued to carry out artificial menopause in recurrent and inoperable cases at these hospitals, and in addition have offered and employed the procedure prophylactically after radical mastectomy in young women. Thus we are able to present briefly an additional series of 50 cases of therapeutic artificial menopause in which patients were treated between January, 1935, and April, 1937.

THERAPEUTIC ARTIFICIAL MENOPAUSE

These patients varied greatly on admission in the extent and stage of the disease. Many were advanced, untreated cases; others presented lesions otherwise operable in whom x-ray examination detected early metastatic involvement; still others represented recurrent disease, locally or metastatically, after radical or subradical surgery. It is difficult to reduce such a group to a common basis for analysis. Twenty patients showed possible or probable benefit from the procedure. In many cases, when the focus of disease could be radiated, the regression may have been due in part to the local radiation rather than to the menopause. This applies particularly to recurrent nodules in the operative area, or to supraclavicular lymph node metastases, in which local radiation is found to be particularly effective.

Among the 20 patients with probable or possible benefit, 9 patients showed regression of bone metastases of greater or lesser extent, ranging from complete regression and recalcification to a change from osteoclastic to osteoblastic bone lesions. Six patients with recurrence in the operative area or supraclavicular area showed marked improvement, but again it must be emphasized that these cases also had the benefit of intensive local x-ray therapy. One patient with pleural effusion, and another with ascites, were relieved of the necessity of frequent paracenteses. There was apparent regression of pulmonary metastasis in 1 instance. Finally, in 2 patients with rather widespread involvement, the progress of the disease seemed to be definitely arrested, in 1 patient for several months and in the other for a period of about 2 years.

Of the entire group of 50 cases, 42 patients are dead, 1 remains untraced, and 7 are still living without evident active progress of the disease.

From the Collis P. Huntington Memorial and Pondville State Hospitals.

Presented in the Symposium on Cancer, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1937.

CASE REPORTS

CASE 1. No. 10707. The patient, aged 43 years, had a radical mastectomy performed in October, 1933. She was admitted in April, 1936, bedridden with generalized skeletal metastases. Artificial menopause was employed in May, 1936. Reports by letter dated November, 1937, state that she is up and about, driving an automobile, doing housework, and feeling better than she has in years.

CASE 2. No. 10139. This patient, who was 50 years of age, had a radical mastectomy performed in June, 1932. The axillary nodes were involved. There was a supraclavicular node recurrence in November, 1935, when artificial menopause and local x-ray treatment were employed. In January, 1938, no evidence of active disease was seen but there was paralysis of the left vocal cord.

CASE 3. No. 6132. The patient, aged 37 years, had carcinoma of the breast and axilla, with cranial metastases. Radium implantation to breast and axilla was applied in May, 1933, artificial menopause was employed in October, 1933; and complete regeneration of cranium was observed in March, 1935. New cranial metastases involving orbit occurred in May, 1937. Her condition was unchanged, but there were no further symptoms in October, 1937.

CASE 4. No. 4950. The patient, 42 years of age, had a radical mastectomy performed in December, 1932. The axilla was not involved. She received postoperative x-ray therapy. In December, 1934, there was a recurrence in lung and mediastinum. Probably spontaneous menopause had occurred in 1933. She received pelvic radiation in February, 1935, and in June, 1938, there was no evident disease. Chest x-ray was unchanged, and there was question of radiation fibrosis.

CASE 5. No. 35–949. The patient, aged 35 years, had a simple mastectomy performed in May, 1935. There was a recurrence in the scar in August, 1935, and local x-ray treatment was used. Artificial menopause was employed in December, 1935. In February, 1936, there was a local recurrence plus axillary nodes for which local x-ray treatment was applied. Menses returned in October, 1936, when she received additional x-ray treatment to pelvis. In March, 1938, there was no evidence of disease.

CASE 6. No. 33–1540. Biopsy was performed in 1929, upon the patient, 34 years of age, and radical mastectomy followed 2 weeks later. There were local recurrences in April, 1933, which were excised. Multiple skin nodules, axillary and supraclavicular metastases appeared in December, 1933, and she received local x-ray therapy. Arti-

TABLE I.—AXILLARY INVOLVEMENT ON ADMISSION

	Age	
	Under 46 Per cent	Over 60 Per cent
Axilla not involved	23	43
Axilla involved	77	57

ficial menopause was employed in April, 1934. There was no evidence of disease in August, 1938.

CASE 7. M. C., aged 33 years, had a radical mastectomy performed in April, 1927. The axillary nodes were involved. Pleural metastases appeared in 1933 and there were recurrences in the scar tissue in 1934. Local x-ray therapy was applied with multiple thoracenteses. Artificial menopause was employed in 1935, and further thoracenteses were unnecessary. In August, 1938, she was troubled with cough and dyspnea, but x-ray findings were unchanged. There was some question of pulmonary fibrosis.

It is of interest to compare the present group with other published series of cases. Dresser found benefit in about a third of his cases. Ahlbom reported that about 70 per cent of his cases were improved, but he made no attempt to rule out the benefit attributable to local radiation therapy. Most of the scattered individual case reports record benefit to patients with bone metastases. Regression of pulmonary or visceral metastases are rarer, although Dresser reported a case of regression of pulmonary metastases. Skin and scalp nodules have disappeared in some cases, even when no local therapy is employed. The regression noted by earlier advocates of surgical menopause, Schinzinger, Beatson, Thomson, Lett, and others, was limited to the demonstrable superficial lesions. The authors also reported improvement in about one third of the cases subjected to castration. We are unaware of any cases of regression of liver or brain metastases. Inflammatory carcinoma does not often show notable benefit following artificial menopause (10).

Many of the patients, who are to benefit by the procedure, experience a marked improvement in their sense of well-being. Often they gain in weight and appetite, simultaneously with the arrest in progress of the disease. This general improvement occurs in favorable cases in spite of the existence of the menopausal symptoms which, in these patients, are often particularly troublesome.

We may conclude that as a therapeutic procedure, artificial menopause is of definite palliative benefit to about one-third of the patients with inoperable or recurrent carcinoma of the breast. The most striking and, in most instances, the most durable results are evident in the group suffering from osseous metastases. While adequate data are lacking, it is probable that life is prolonged in many of the patients. It is unlikely that patients with visceral metastases benefit very often from the procedure. We have observed no such encouraging cases, as those reported by Clarkson and Barker, in which apparent cure resulted from artificial menopause combined with intensive local x-ray therapy. In general it is fair to say that the benefit is transitory and capricious, although the occasionally gratifying results and the virtually negligible inconvenience would seem to justify the procedure in young women who are suffering from incurable disease.

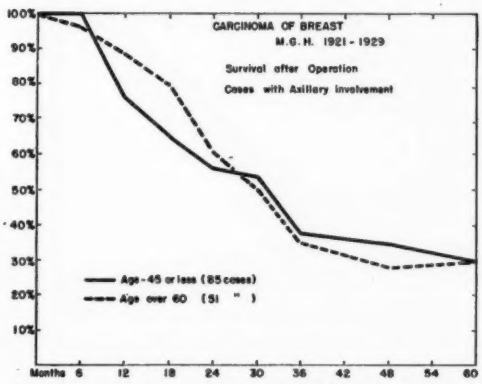


Chart 1. Carcinoma of the breast, Massachusetts General Hospital, 1921–1929; survival after operation; cases with axillary involvement.

PROPHYLACTIC ARTIFICIAL MENOPAUSE

Encouraged by the results in recurrent and inoperable disease, we have employed artificial menopause as a prophylactic procedure in young women following radical mastectomy for operable carcinoma of the breast. Forty-seven of these cases are available for study, of which 14 patients had no axillary node metastases, while 33 presented positive axillary nodes. Of the early and favorable cases 1 patient died of liver and cerebral metastases, and the 13 remaining are living, apparently free from disease for an average

TABLE II.—PATHOLOGICAL GRADE OF MALIGNANCY

	Age	
	Under 46	Over 60
No. of cases	146	156
	Per cent	Per cent
Grade I	7	16
Grade II	49	56
Grade III	44	28

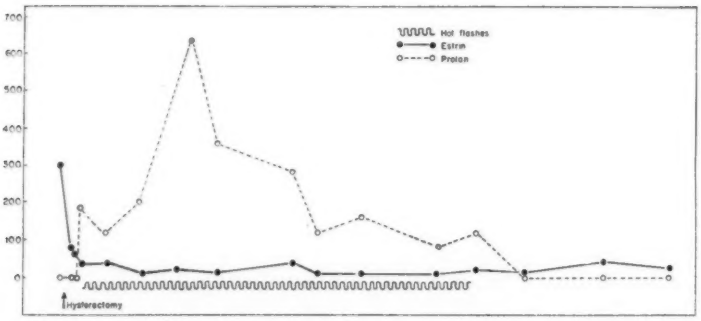


Chart 2. Surgical menopause. Hysterectomy and bilateral oophorectomy. Solid line: urinary estrin excretion in international units; dotted line: urinary prolan A excretion in mouse units.

period of 2.8 years after operation. Of the 33 patients with axillary involvement, 15 are dead, 3 are living with probable recurrence, and 15 are living without evidence of disease for an average period of 2.7 years after operation.

Obviously it is premature to attempt any appraisal of the value of artificial menopause in this group. Accurate knowledge of the expected results must be available in a comparable group of radical operations in young women without artificial menopause. Such a study was carried out and reported in 1936 (11), in which 5 year end-results in a group of young women were contrasted with results in older women. Briefly, it was demonstrated that carcinoma of the breast tends to metastasize earlier in young women, that it tends to be of higher grade of malignancy, and that postoperative recurrence takes place a little more promptly. These findings are presented in Tables I and II and Chart 1. As a result of the study it was concluded that in carcinomas of the breast of equivalent extent and of equal grade of malignancy, age alone does not affect curability (Table III).

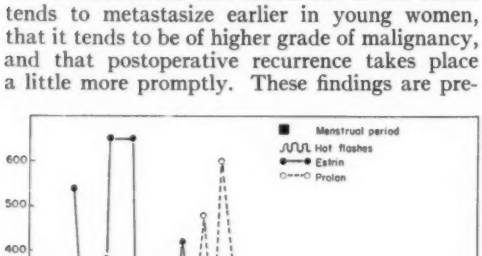


Chart 3. Successful radiation menopause. Solid line: urinary estrin excretion in international units; dotted line: urinary prolan A excretion in mouse units.

Reverting to Chart 1, it can be seen that the curve of survivals of both age groups is close to 50 per cent at the end of 30 months after operation. This corresponds to the figure for our artificial menopause group with axillary metastases at an average interval of 2.7 years after operation. Obviously, the curve for the artificial menopause group may flatten out hereafter, although from the chart it can be seen again that from this point onward the young and old groups run parallel courses. Hence it may be concluded that we have thus far observed nothing in our study to warrant the conclusion that artificial menopause is likely to be of striking benefit as a prophylactic procedure against recurrence after radical mastectomy.

We turn to the laboratories and hormonological studies for an explanation of the benefits which do take place in some of the recurrent cases. Studies of estrin and prolan A, or the follicle-stimulating hormone, levels in carcinoma of the breast cases show no significant differences from levels in control individuals. The effect of artificial menopause on these levels is illustrated in Charts 2, 3, and 4 (7).

TABLE III.—CURES WITH RADICAL OPERATIONS

	Age	
	Under 46	Over 60
Cases	117	113
	Per cent	Per cent
Cures	34	44
Axilla not involved	71	67
Axilla involved	20	21

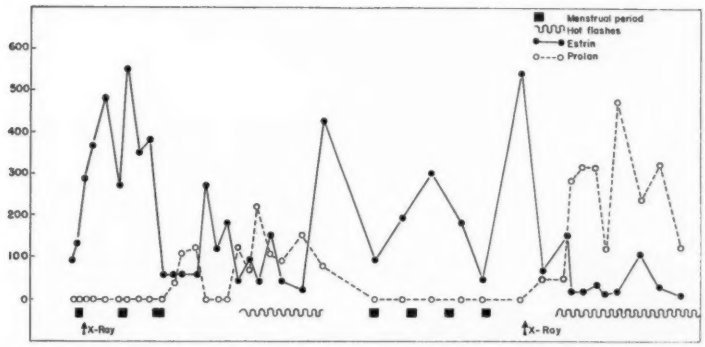


Chart 4. Unsuccessful radiation menopause. Solid line: urinary estrin excretion in international units; dotted line: urinary prolan A excretion in mouse units.

Note that in the case of oophorectomy (Chart 2), the estrin level falls at once to a low level where it remains. This is accompanied by a rapid rise in the prolan A excretion, accompanied by hot flashes. The successful radiation menopause (Chart 3), shows similar curves, although the response is not so prompt. In the case of inadequate radiation (Chart 4), note that the estrin does not fall to the low menopausal level, but that it shows marked irregularities. Resumption of menses is heralded by a marked rise in the level of estrin and by a sharp drop in prolan A.

Are we justified in assuming that the benefits observed in certain of the cases are due to the low estrin level obtained, either directly or through the compensatory response of the anterior pituitary hormones? Are we concerned with the effect of estrin on the calcium metabolism in accounting for the regressions of bone metastases? These are questions which cannot be answered authoritatively on the basis of available knowledge. It seems, in these cases which show favorable response to menopause, as if the tumor growth is unusually dependent on the presence of considerable amounts of estrin; and that removal of this growth stimulus temporarily results in retardation or actual regression in the disease.

The experimental work of Lacassagne, Loeb, his co-workers, and others, prepares us to accept the etiological significance of estrin in carcinoma of the breast. As far as we are aware, none of the experimental work justifies the assumption that growth of the tumor is dependent on a continuance of estrin stimulation after the development of malignancy has once taken place. If this assumption be correct, it seems unnecessary to point out that the menopausal symptoms, which may take place, should not be treated by the administration of estrin.

We turn to the pathologists in vain for a definition of characteristics of the growth which would indicate a likelihood of favorable response. Until they can do so, we must continue to give the possible advantage to all cases of recurrent and inoperable disease, with the reasonable hope that a certan num ber of the patients will benefit as a result. i

CONCLUSIONS

Artificial menopause may be expected to result in temporary regressions or improvement in about one-third of the cases with recurrent and inoperable carcinoma of the breast. The most striking benefit appears to accrue in cases with osseous metastases.

Artificial menopause cannot be demonstrated as advantageous when employed as a prophylactic procedure in patients who are submitted to radical operation.

Hormone studies are thus far unable to explain why the favorable effects take place; and pathological studies are unable to predict which cases will react favorably.

BIBLIOGRAPHY

1. Ahlbom, H. Castration by roentgen rays as an auxiliary treatment in the radiotherapy of cancer mammæ at Radiumhemmet, Stockholm. Acta Radiol., 1930, 2: 614–633.
2. Beatson, G. T. The treatment of inoperable carcinoma of the female mamma. Glasgow M. J., 1911, 76: 81–87.
3. Clarkson, W., and Barker, A. Five year cure of mammary carcinoma with multiple metastases to bone. Am. J. Roentgenol., 1936, 36: 615–621.
4. Dresser, R. The effect of ovarian radiation on the bone metastases of cancer of the breast. Am. J. Roentgenol., Mar., 1936, 35: 384–388.

5. LACASSAGNE, A. Hormonal pathogenesis of adenocarcinoma of the breast. Am. J. Cancer, June, 1936, 27, 2: 217–228.
6. LETT, H. An analysis of 99 cases of inoperable carcinoma of the breast treated by oophorectomy. Lancet, 1905, 1: 227–228.
7. NATHANSON, I. T., et al. To be published.
8. SCHINZINGER. Das Karzinom der Mamma. Muenchen. med. Wchnschr., 1905, 52: 1724–1725.
9. SUNTZEFF, V., BURNS, E. L., MOSKOP, M., and LOEB, L. The effect of injections of estrin on the incidence of mammary cancer in various strains of mice. Am. J. Cancer, June, 1936, 27, 2:229–245.
10. TAYLOR, G. W., and MELTZER, A. Inflammatory carcinoma of the breast. Am. J. Cancer, 1938, 32: 33.
11. TAYLOR, G. W. Carcinoma of the breast in young women. New England J. Med., Dec. 31, 1936, 215, 27: 1276.
12. THOMSON, A. Analysis of cases in which oophorectomy was performed for inoperable carcinoma of the breast. Brit. M. J., 1902, 2: 1538–1541.

PALLIATIVE IRRADIATION OF METASTATIC TUMORS IN THE LUNGS

ALEXANDER BRUNSCHWIG, M.D., F.A.C.S., and ANNA HAMANN, M.D., Chicago, Illinois

THE rather limited literature on irradiation therapy of pulmonary metastases has been reviewed recently by Treves. This author also cites 38 cases from the Memorial Hospital, New York, of pulmonary metastases from breast carcinoma, which were treated by irradiation, and compares them with 21 similar cases that did not receive such treatment. The average duration of life after treatment was 11.4 months whereas in the untreated cases it was 35.9 months. While isolated instances of improvement following irradiation therapy are admitted, the general conclusion is, that with rare exceptions, roentgenotherapy is of doubtful value in controlling mammary cancer which has invaded the lung.

This report includes the results obtained by irradiation of pulmonary metastases from various types of primary growths outside the thorax observed in 13 cases of the University of Chicago Clinics. These are summarized in the accompanying table.

In every case there was histological verification of the nature of the primary tumor. The diagnosis of metastatic pulmonary lesions was based upon roentgenographic appearances of the chest and in every instance, except in Case 5, the lesions were discrete, rounded masses and not diffuse shadows which are always more questionable. Necropsy was obtained in the majority of patients who died confirming the roentgenographic diagnosis.

Additional reports, not included in Treves' review, are those of Hohlfelder of a patient with pulmonary metastases from thyroid carcinoma who survived 8 years; Schulte reports a case of pulmonary metastases from Ewing sarcoma which regressed completely from the roentgenographic standpoint following irradiation, the patient dying 2 years later of sarcomatosis; and Fussl reports a case of thyroid carcinoma metastases which regressed after irradiation and the patient survived 4½ years.

From the Department of Surgery and the Division of Roentgenology of the Department of Medicine, University of Chicago Clinics.

Presented in the Symposium on Cancer, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

Case number 523 in the Bone Sarcoma Registry is a white female presenting an advanced sarcoma of the left ilium in 1922, which was treated by irradiation. In the same year roentgenographic evidence of advanced metastases in both lungs was observed and the chest irradiated. The metastases disappeared and when last seen in 1938, 16 years later, the lungs were clear and there was no evidence of active disease.

ANALYSIS OF SERIES

In the series of 13 cases shown in Table I, complete, immediate regression of the metastases from the roentgenographic standpoint was observed in 9 instances. Five of these 9 patients died in 3 months to 1 year of carcinomatosis including recurrences in the lungs. Of the 4 patients remaining, 3 are alive 19 months, 21 months, and 7 years respectively, without roentgenographic evidence of active neoplasm in the lungs; and 1 died 18 months after treatment of an intercurrent complication, but at necropsy no evidence of malignant tumor was present at the site of metastasis, that is, in the mediastinum.

Dosage. Experience has shown that pulmonary metastases often exhibit a marked degree of radiosensitivity, even greater apparently than the primary growth. The explanation for this of course remains obscure but some of the factors may be vascularity and difference in "soil." The calculated tumor doses, employed in the series here reported, vary widely, and it is interesting to note that the small to moderate doses were as effective as the large doses.

Technique. The technique employed was as follows: 200 kilovolts, .5 to 1 millimeter of copper, plus 1 millimeter of aluminum filtration 5 to 25 milliamperes, 50 to 80 centimeters F.S.D.; 10 by 10 centimeter to 20 by 20 centimeter ports on the anterior and posterior chest walls depending on number and size of lesions. Only the affected lungs were treated; the whole chest was exposed only when the metastatic lesions were bilateral.

No attempt is made to include all cases of pulmonary metastases treated, and to arrive at some mathematical expression of the probability of regression or prolonged survival following treat-

Fig. 1. Roentgenograms of chest showing extensive pulmonary metastases from embryonal carcinoma of testis before October 1, 1934, and November 23, 1938, after x-ray therapy. Patient died 4 months later of generalized metastases but the case illustrates the phenomenal regressions that sometimes obtain in very radiosensitive tumors.

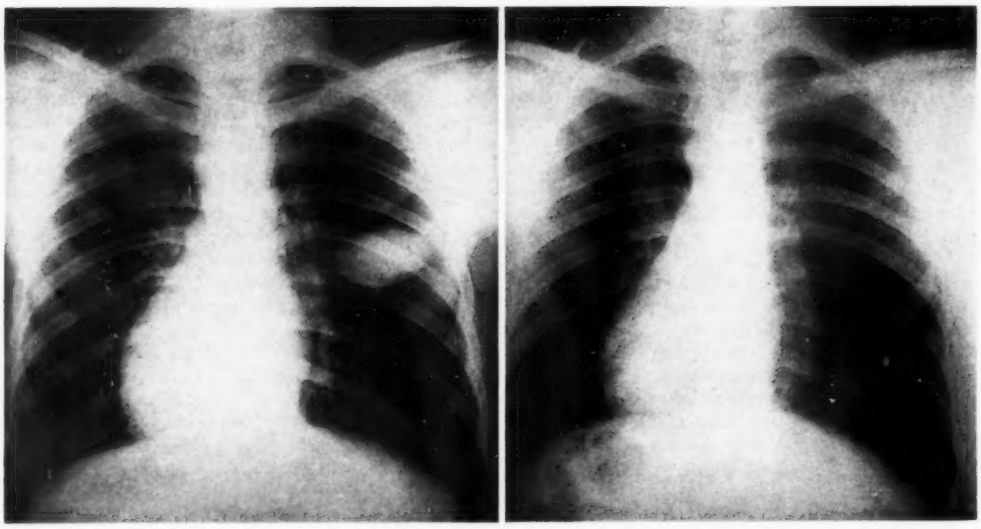


Fig. 2. Roentgenograms of chest of patient with Ewing sarcoma of the pelvis and large pulmonary metastasis in right lung. The primary lesion was treated by means of irradiation and 6 months later, when these roentgenograms were taken, the metastatic lesion was similarly treated and this therapy was followed by complete regression. The patient is free from evidence of active disease 24 months later.

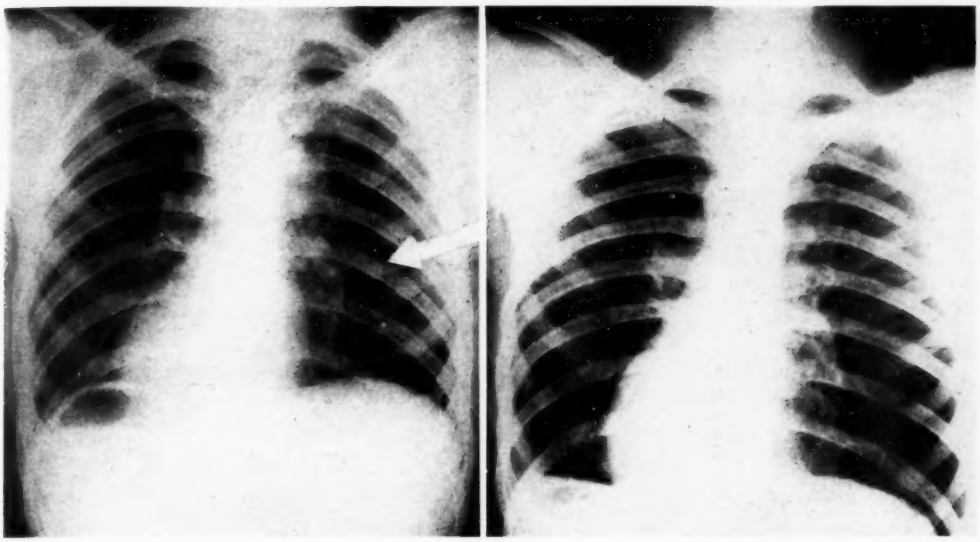


Fig. 3. Roentgenograms of chest of patient with Ewing sarcoma of pelvis and solitary metastatic mass in right lung. The primary lesion was treated by means of irradiation as was the pulmonary lesion 6 months later. There was complete regression of the pulmonary lesion following treatment, and 21 months later the patient remained free from evidence of active disease.

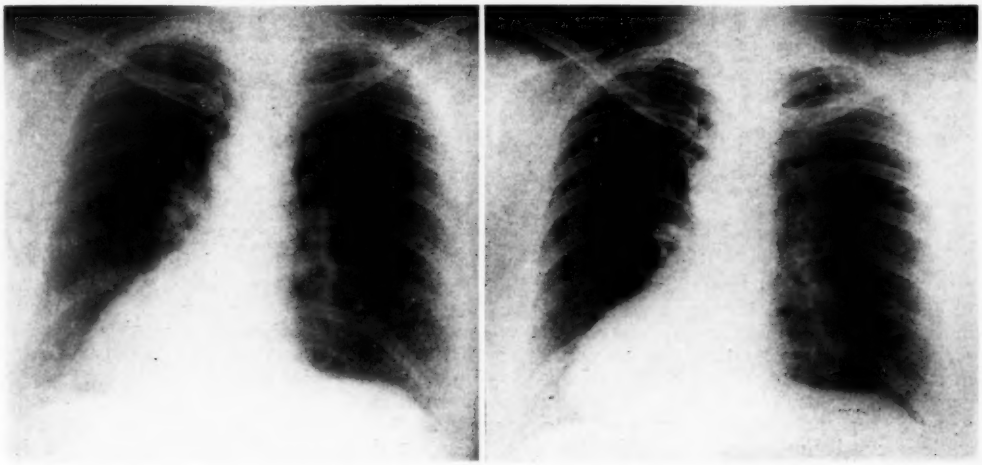


Fig. 4. Roentgenogram taken October 28, 1931, shows rounded mass in lower left lung, characteristic of a metastatic growth. One year previously the right leg was amputated for sarcoma of the lower femur. Following irradiation therapy to the pulmonary lesion there was complete regression. The roentgenogram taken April 9, 1936, shows no evidence of metastatic lesions and the patient is at present well and clinically free from active disease 7 years later.

TABLE I.—RESULTS OF IRRADIATION THERAPY ON 13 PATIENTS WITH PULMONARY METASTASIS

Patient, age, sex, Hospital No.	Primary lesion	Roentgenograph of chest	X-ray therapy calculated effective tumor dose	Immediate results (roentgenographic appearance)	Subsequent clinical course
1. G.F., 32, ♂ 106534	Embryonal carcinoma of testis	Large rounded masses in both lungs	2430 r in 107 days total to both lungs	Complete regression of masses in both lungs	Died 4 mos. later of generalized metastasis; tumor nodules in lungs at necropsy
2. R.A., 25, ♂ 119667	Embryonal carcinoma of testis	Large rounded masses in upper lobes of both lungs	1900 r in 18 days total to both upper lobes	Complete regression of masses in both lungs	Subsequently died; period of survival unknown
3. W.K., 40, ♂	Embryonal carcinoma of testis	Large rounded mass in upper mediastinum	1094 r in 36 days	Complete regression of mass	Died 18 mos. later, peritonitis; necropsy showed no evidence of mediastinal tumor
4. L.C., 55, ♂ 79351	Carcinoma of kidney	Large rounded mass at mid portion of right lung	5800 r in 29 days	Complete regression of mass	Died of generalized metastasis 8 mos. later
5. M.L., 51, ♀ 974	Carcinoma of breast	Moderate size masses in right lung	3150 r in 4 mos.	Partial regression of metastases	Died 1 yr. later of carcinomatosis
6. H.V., 33, ♀ 97464	Carcinoma of breast	Multiple rounded masses in both lungs	2500 r to each lung in 5 mos.	Marked regression of metastatic masses	Died of carcinomatosis 8 mos. later
7. C.N., 50, ♀ 170708	Carcinoma of breast	Multiple rounded masses in both lungs	1050 r in 6 mos. to whole chest	Marked regression of metastatic masses	Alive 14 mos. later—clinically much improved
8. G.P., 44, ♂ 164715	Hypernephroma of kidney	Rounded masses in lower portion of left lung	1600 r in 22 days	Marked regression of metastatic masses	Clinically much improved 2 mos. later
9. H.P., 53, ♂ 185288	Round cell sarcoma (fascial) of thigh	Multiple rounded masses at base of right lung	1600 r in 10 days	Complete regression of masses	Recurrent metastatic masses in both lungs and sarcomatosis; died 4 mos. later
10. H.C., 19, ♂ 83558	Ewing sarcoma of pelvis (primary lesion treated by x-ray)	Simple rounded mass at mid portion of right lung	700 r in 7 days	Complete regression of mass	Clinically free from active disease 21 mos. later
11. S.E., 21, ♂ 156138	Ewing sarcoma of pelvis (primary lesion treated by x-ray)	Large mass at mid portion of right lung	1200 r in 9 days	Complete regression of mass	Clinically free from active disease 24 mos. later
12. M.B., 46, ♀ 27359	Fibrosarcoma of lower femur (amputation)	Solitary rounded mass at mid portion of left lung	800 r in 4½ mos.	Complete regression of mass	Well 7 yrs. later
13. C.E., 62, ♀ 159597	Carcinoma of right breast	Multiple rounded masses in left lung	2364 r in 60 days	Complete regression of masses	Lived 1 yr., died of carcinomatosis

ADDENDUM TO TABLE

Case 3. Patient developed necrosis of a portion of the transverse colon which was in irradiated field over large retroperitoneal metastatic mass, treated at same time as mediastinal lesion (see report by Brunschwig and Fox).

Case 5. Patient developed bronchopneumonia complicating metastases in lungs. This resorbed and patient lived several months in fair condition. She also had skeletal metastases.

Case 6. Patient received x-ray therapy to head for intracranial metastases producing severe symptoms of brain tumor and also x-ray therapy to large hepatic mass, while receiving therapy to lungs. During period of palliation the patient lived almost a normal existence.

Case 7. Extensive skeletal metastases causing severe pain also irradiated with considerable relief from pain.

Case 12. Roentgenograms of chest, taken at interval of 16 weeks before irradiation was given to lung, showed no apparent increase in size of metastatic mass. This fact does not in itself indicate that the lesion observed was something other than a metastatic growth since pulmonary metastases have been observed to appear stationary for long periods; the nature of such lesions has been verified at necropsy. (See report by Fussl.)

ment in any series of patients. This would hardly be possible in view of the very marked variation in the clinical picture presented by each case, such as the general condition, site and number of metastases elsewhere than in the lungs, type of neoplasm, age, etc. While this series of patients is not an especially selected one, it does not include an equal number of patients with extensive pulmonary and other metastases, who were also treated but with no appreciable results.

The purpose of this report is to demonstrate that immediate marked or apparent complete regression of pulmonary metastases in roentgenograms of the chest may not infrequently follow irradiation therapy; and that this, as occurred in the above series, is accompanied by a varying degree of palliation of local and general symptoms for a brief or a more prolonged period. The argument that such treatment may entail eventual tissue damage and augment the general depression resulting from anemia, etc., would not appear to be a serious contra-indication to such treatment, since small to moderate doses have in this series proved effective, and measures may be adopted to combat anemia which such doses might induce.

It is not intended to carry the impression that irradiation therapy of pulmonary metastases offers a means to alter noticeably the course of the advanced stage of malignancy as found in large numbers of patients. It is believed, however, that such a procedure, when followed judiciously, offers a possibility of palliation in certain individual cases, especially when the general condition of the patient is not bad at the time such metastases are first observed.

CONCLUSION

Moderate irradiation of pulmonary metastases from malignant tumors is indicated as an attempt at palliation in cases in which evidence of such metastases is first discovered, and in cases in which the general condition of the patient is at least fair.

BIBLIOGRAPHY

1. BRUNSCHWIG, A., and FOX, F. Correlation of roentgen ray dosage and necropsy findings, etc. Ann. Surg., 1937, 105: 265.
2. FUSSL, E. Der metastatisch lungen Karzinose Roentgenpraxis. Strahlentherapie, 1937, 9: 184.
3. HOHLFELDER, H. H. Tiefentherapie. Leipsig: Georg Thieme, 1938.
4. SCHULTE, G. Erfolge bei Knochentumoren. Strahlentherapie, 1936, 57: 370.
5. TREVES, N. Is roentgen irradiation of value in the treatment of pulmonary metastasis from mammary cancer? Am. J. Roentgenol., 1938, 39: 783.

THE SURGICAL TREATMENT OF CARCINOMA OF THE LARYNX

GORDON B. NEW, M.D., F.A.C.S., Rochester, Minnesota

SURGICAL intervention has proved to be the most efficient method of treating patients with carcinoma of the larynx. The surgeon, however, in order to give all patients with this disease the best that can be offered and taking into consideration those who are poor surgical risks and inoperable cases, must be able to employ not only pure, surgical procedures but, in addition, surgical diathermy, radon seeds inserted under suspension laryngoscopy, and external irradiation.

DIAGNOSIS

Growths in the supraglottic region may produce few, if any, symptoms until they are large, so that growths of the epiglottis are frequently overlooked. The patient may have an undetermined pain or ache in the throat with little difficulty in swallowing, and the growth, particularly if it be situated on the posterior surface of the epiglottis, may evade inspection unless a careful examination is made. Until these growths have extended into the larynx, hoarseness is not produced.

Growths of the glottis cause hoarseness as an early symptom, so that adult patients, who are hoarse over a period of a month, should have a careful examination to make sure that the hoarseness is not due to a malignant lesion. It is generally thought that malignant tumors of the larynx usually occur in men. While this is true, one sees many malignant tumors of the larynx in women in whom a thyrotomy and, in some cases, a laryngectomy is necessary.

Age should not be a factor in deciding the likelihood of a malignant tumor, as the ages of the patients at The Mayo Clinic, on whom it has been necessary to perform laryngectomy, ranged from 16 to 77 years. In the uncertain case preliminary biopsy is always advisable, the patient and his relatives understanding the surgical procedure that should follow the positive histological diagnosis. I do not think it advisable to perform a biopsy in a possibly malignant laryngeal lesion unless treatment is to follow immediately.

From the Section on Laryngology, Oral and Plastic Surgery, The Mayo Clinic.

Presented in the Symposium on Cancer, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

After excluding the usual conditions considered in differential diagnosis of malignant tumor of the larynx, that is, tuberculosis, syphilis, benign tumors, and granulomas of contact ulcers and some of the more unusual lesions, there remains a group of patients with pathological conditions of the larynx in which it is impossible to make a definite clinical diagnosis. In this group of patients, exposing the larynx by means of suspension laryngoscopy is a valuable aid, not only in the diagnosis but also in the treatment of many of these laryngeal lesions. Many larynges, presenting thickening caused by inflammation, thickened leucoplacias, areas of epithelial hyperplasia and other so called precancerous lesions, are better visualized by binocular examination as obtained under suspension laryngoscopy. This type of laryngoscopy is used with intratracheal gas and ether anesthesia and allows of an excellent exposure of the larynx. In this way an accurate biopsy may be obtained.

In cases in which histological examination of the fresh frozen section proves the condition to be a benign one, such as leucoplacia, epithelial hyperplasia caused by inflammation or a very small early epithelioma, the lesion may be destroyed under suspension laryngoscopy with a long, protected surgical diathermy point. Before diathermy is used, the etherization of the patient is discontinued and he is allowed to take several deep breaths. The anesthesia is then continued with nitrous oxide only. In those cases in which benign lesions and early epitheliomas are removed endoscopically by surgical diathermy, careful surgical judgment must be used in selection of patients. In elderly patients and patients that are bad surgical risks, the results show that this method of removal can be used with much less danger and with a good prognosis in selected cases. In the cases in which the lesion is more extensive, suspension laryngoscopy allows of a thorough examination and a decision may be made at the time as to whether a thyrotomy and exploration or a laryngectomy should be done.

METHODS OF SURGICAL REMOVAL

Surgical procedures, including removal and surgical diathermy, are the most effective methods

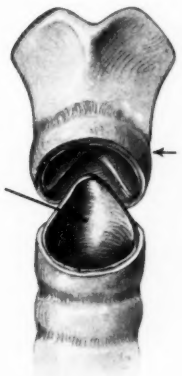


Fig. 1. The mucous membrane flap, indicated by long arrow, that is dissected from the posterior wall of the cricoid cartilage, indicated by short arrow, in cases in which the situation of the growth will permit.

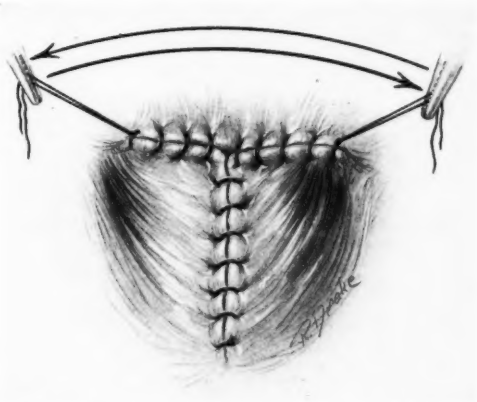


Fig. 2. Closure of the pharynx with two rows of chromic catgut sutures in the shape of a T.

of treating carcinoma of the larynx. In addition to these, however, the use of radon seeds and external irradiation is of great value in many cases. It is the evaluation of the various methods of treatment and their application to the individual case that makes the most efficient method of treatment for malignant tumor in its various locations and types. In determining the best method of treatment, the duration of the history of hoarseness, the location of the lesion and its extent, the histological grade of the tumor, the question of metastasis, the patient's age and general condition as to surgical risk, must all be considered. These are all questions which play an important part in the surgeon's decision.

Carcinoma of the larynx may be divided into 3 groups: (1) the supraglottic growths; (2) the intralaryngeal growths, including the subglottic; and (3) laryngopharyngeal growths arising in the pyriform sinus or the postcricoid region. Many of these growths may involve one or possibly more of the regions but the smaller growths will come under this grouping. The type of carcinoma present may be determined by the appearance of the tumor and the microscopic grading. Unless the type of growth is such that it can be cared for in a conservative way and the excision made well wide of the growth, a more extensive operative procedure should be employed. The work of New and Fletcher on the selection of treatment for carcinoma of the larynx brought out the fact that the low-grade tumor could be removed with a much narrower margin than the more active growths.

The patient's age and general condition are very important factors in determining the treatment. Patients more than 75 years of age or those with poor general conditions, such as bronchiectasis, diabetes, or angina, are subject to added surgical risks and while they may withstand a major surgical procedure, a less radical one is advisable sometimes under the circumstances. It is in these elderly patients that a two stage operation, of which the first is a preliminary tracheotomy, is of great value In some of those, too, the use of suspension laryngoscopy and removal of the growth perorally is advisable, and in some external irradiation only is employed. In many cases it is necessary to do a thyrotomy as an exploratory operation before the particular surgical procedure to be employed can be decided on. While conservation of the voice must be considered whenever possible, the eradication of the disease is of the first importance.

Supraglottic growths. Tumors of the epiglottis are usually of a low grade of malignancy. However, tumors of the base of the tongue of a high grade of malignancy may involve the epiglottis. In growths in which the lesion is limited to the epiglottis, removal with surgical diathermy under suspension laryngoscopy gives excellent results. Even in cases in which the growth involves the base of the tongue, it may be thoroughly removed with diathermy and radon seeds can be inserted into the involved area. To illustrate how extensive destruction may be accomplished by this method, in 1 case I removed the inner surface of the hyoid bone as a sequestrum. The patient, who had an extensive squamous-cell epithelioma,

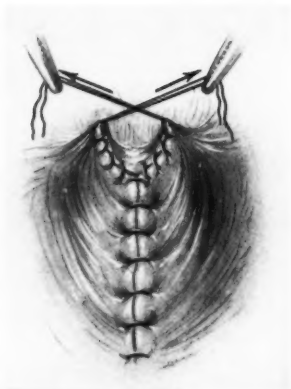


Fig. 3. Tying of the sutures at the extremities of the horizontal portion of the T, in this way burying the upper portion of the wound.

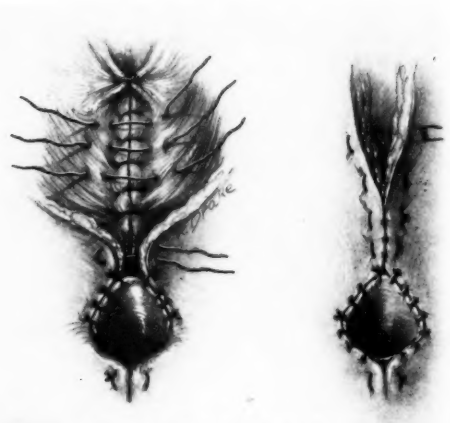


Fig. 4. Left, the pharynx is closed with a second row of chromic catgut sutures. Silk sutures approximate the skin and tongue-shaped flap. A mattress suture, which is carried through the anterior wall of the esophagus, closes the skin above the trachea. Right, mattress sutures complete the closure of the skin above the trachea. The lateral Penrose cigarette drains and the iodoform-gauze pack in the upper portion of the wound are not shown.

grade 4 on a basis of 1 to 4, was well at the time of this writing, which is more than 5 years after operation.

In the supraglottic tumors in which the aryepiglottic fold is involved, pharyngotomy through the thyrohyoid membrane or lateral pharyngotomy is the treatment of choice. In this way a wide exposure can be made and as radical an excision performed as is necessary. At times a window may be removed from the thyroid cartilage on the opposite side to the growth, or the thyroid cartilage divided, allowing an excellent exposure through which the growth may be destroyed with surgical diathermy. A transmandibular and translingual exposure, as used by Trotter to remove epiglottic growths, is technically an excellent operative procedure, but I feel that other methods are far more efficient and that they result in a much lower operative mortality.

Carcinoma of the epiglottis may fill almost the entire hypopharynx so that only a margin of the larynx is visible. There is a tendency for these low grade tumors to be more of an excrescence, like a cauliflower that has gone to seed, than an invading growth. If the growth is an infiltrating one without limited margins, removal under suspension laryngoscopy should not be attempted. In some supraglottic growths, which involve the aryepiglottic fold and the pyriform sinus, laryngectomy along with removal of a portion of the lateral wall of the pharynx is feasible. The type of operation and the technical procedure which are to be employed should be suited to the individual lesion.

Intralaryngeal growths. Malignant lesions involving the inside of the larynx may be taken care of in several ways. Thyrotomy and exploration are advisable in many cases in which the exact limits of the lesion are undetermined, and in which there is a question as to whether a conservative operation or a laryngectomy is advisable. Surgical diathermy is used in all cases in which thyrotomy is employed. The early lesion without fixation is widely removed and the base destroyed with diathermy. When the lesion is more advanced with possibly some limitation of movement involving the anterior two-thirds of the vocal cord, the growth is removed along with the cartilage and the base is destroyed with diathermy. This is really a hemilaryngectomy. In growths involving one vocal cord and the anterior commissure without fixation, or in which the anterior commissure is involved along with the anterior half of both vocal cords, the method suggested by Jackson for low-grade tumors gives excellent results. One must remember, however, that frequently growths involving the anterior commissure may extend through the cricothyroid membrane; and also that in highly malignant growths one cannot get a wide enough margin unless the anterior portion of the thyroid cartilage is removed as well as the soft tissues. If a wide removal is made in this manner, the patient may still have an airway and a passable voice. Laryn-

gectomy is done in more extensive lesions in which, owing to the size, location, and type of the growth, a conservative removal, which allows of a sufficient margin of safety, cannot be performed.

When laryngectomy is done, I use paravertebral anesthesia and I prefer the midline incision. I then divide the hyoid bone and retract it laterally with rake retractors. The larynx is freed from the muscles, first on one side and then on the other. On account of the possible extension of the growth through the thyroid cartilage or the cricothyroid membrane, it is essential that this dissection be made very carefully. If there is any question of extrinsic involvement at this point, wide excision, either with a knife or with surgical diathermy, is advisable. The trachea is cut across below the growth and procaine is then injected into the posterior wall of the larynx and trachea. If the extent of the growth will permit, a tongue-like flap of mucous membrane and submucous tissue is dissected free from the posterior wall of the cricoid cartilage, leaving it attached to the tracheal mucous membrane (Fig. 1). This aids in the closure of the skin to the trachea. It is necessary to inject some procaine into the pharynx after the trachea has been cut across, since it is difficult to block this area with paravertebral anesthesia.

Dissection is then carried up onto the posterior wall of the larynx. The pharynx is opened, and in cases in which there is some question as to the posterior extension of the growth, exploration is made with the finger at this time. The larynx is then removed. The opening into the pharynx in the shape of a T is closed with two layers of fine, chromic catgut sutures (Fig. 2). The sutures at the extremity of the crosspiece of the T are left long and after the rest of the pharynx is closed are tied together, thus burying the central portion of the wound (Fig. 3). The trachea is sutured to the skin by means of silk sutures. One mattress suture just above the trachea is carried through the anterior wall of the esophagus in order to bring it forward against the skin. Mattress sutures are used in closing the lower 5 centimeters of the skin above the trachea. Rubber Penrose cigarette drains are carried into the pockets on either side and an iodoform gauze pack is placed in the upper part of the wound. A No. 7 tracheal tube is inserted and a dressing is applied over the upper part of the neck (Fig. 4).

Little reaction follows operation by the procedure I have outlined if a preliminary tracheotomy has been made. The temperature usually does not go above 100 or 101 degrees F. and after about 4 days goes back to normal. The drains are removed gradually; they are usually out about the tenth day. In a large percentage of cases, the closure about the posterior wall of the trachea and lower 5 centimeters of the incision heals almost by primary intention. If, as frequently happens, a small pharyngeal fistula is left at the upper end of the incision, it is freshened up after the wound heals sufficiently and is closed with mattress sutures. The tracheal tube is usually removed about the fourth day and kept out the greater part of the time unless there is some tendency for the tracheal opening to close. In this way less reaction occurs about the upper end of the trachea. In regard to the question of removal of lymph nodes in these cases, I do not do a routine block dissection of the necks of patients who have a malignant lesion of the larynx without involvement of the nodes. In cases in which there is nodal involvement of low grade, I feel that the lymph nodes should be removed. To illustrate the value of neck dissection, 1 patient with squamous-cell epithelioma, grade 2 of the cervical lymph nodes, lived for 18 years after operation and died of adenocarcinoma of the stomach.

Laryngopharyngeal growths. Postcricoid growths are practically always squamous-cell epithelioma, grade 4, but may be of low grade and, as a rule, are found in women. A lymph node is usually palpable at the time of the first examination. Trotter's method of doing a transthyroid pharyngotomy is the treatment of choice if there is no involvement of the lymph nodes and the patient is otherwise a good surgical risk. However, the prognosis in these highly malignant tumors in this region is such that, unless the operation is done early, surgical intervention offers little except in a limited group of cases. Tumors of the pyriform sinus are usually squamous-cell epithelioma, grade 3 or 4, and usually metastasize early.

It is in these two groups of cases, involving the postcricoid region and the pyriform sinus, that external irradiation has accomplished a great deal and in my opinion it should be the treatment of choice. I have had 2 such patients that have been greatly benefited by irradiation.

One was a man, 45 years of age, with the growth involving the arytenoid and postcricoid regions, a squamous-cell epithelioma, grade 3, causing laryngeal obstruction. I performed a tracheotomy and then followed this with roentgen therapy in small fractional doses. The tumor disappeared entirely and the patient has been well with no recurrence 18 months later. The second patient was a man, aged 55 years, with a growth in the pyriform sinus, grade 2, with 2 midcervical lymph nodes that felt malignant. After roentgen therapy the enlargement of the nodes disappeared as well as the local lesion and the patient has been well nearly 2 years.

Neither of these patients would have been benefited by surgical intervention whereas roentgen therapy has obtained an apparent cure. These, however, are only 2 of the many patients who have been treated but they do tend to show that in certain cases the use of irradiation is well worth while.

Quick stated that the present status of irradiation therapy renders total laryngectomy obsolete, that an early malignant tumor is as favorable for irradiation as for surgical extirpation, and that the ultimate results are better. He did not, however, present sufficient evidence to back up such sweeping statements. The end-results in surgical treatment of malignant lesions of the larynx are well known. The operative mortality rate is less than 3 per cent and the end-results show that between 50 and 60 per cent of patients requiring laryngectomy are alive 5 years later. Good speech may be obtained in most patients on whom thyrotomy has been performed by the good vocal cord approximating a scarred band. In patients for whom laryngectomy has been necessary the use of the pharyngeal muscles or an artificial larynx frequently produces much better speech than the pre-operative voice.

The selection of treatment in carcinoma of the larynx requires keen surgical judgment. The laryngologist, who wishes to give efficient treatment to all patients, must use, as they seem indicated, all of the various methods that the medical profession has at its disposal. The problem is to evaluate and apply them efficiently to each individual patient.

X-RAY TREATMENT OF INOPERABLE CARCINOMA OF THE LARYNX

HENRI COUTARD, M.D., Chicago, Illinois

CLINICALLY and histologically there exist 2 main varieties of laryngeal cancer: cancer composed of undifferentiated cells, and cancer composed of differentiated cells. The former live in a loose vasculoconnective tissue which is itself undifferentiated and disorganized. In this tumor bed the neoplastic cells multiply rapidly, at the same time respecting the highly differentiated tissues such as nerves, blood vessels, and muscles. They are in contact by the lymphatic spaces with the lymphatic vessels, and they have a tendency to early and widespread dissemination in the loose vasculoconnective tissue. They are accompanied by early regional adenopathy whose evolution is irregular, sometimes rapid and sometimes stationary, or even regressive when they originate from the vestibule or the ventricular cavity. This type of cancer generally arises in regions which for many years have been the site of acute inflammatory changes, the inflammatory processes having induced certain modifications.

The differentiated variety of cancer cells lives in a dense and highly organized vasculoconnective tissue bed, and sometimes in the muscle itself, for which it has a special affinity. At first these cells infiltrate the intermuscular spaces, afterward penetrating the muscle fibers and causing an early immobilization of the underlying muscle. In regions where they grow the lymphatics and blood vessels are destroyed, the nerves are compressed and the nerve sheaths are infiltrated. Cancers with differentiated cells have no tendency to distant dissemination. They develop slowly and penetrate the lymphatic and vascular tissue later. They are generally of limited extent and of small size. Regional adenopathy is rare. When it occurs, its development is irregular and slowly progressive. These cells appear in a region in which a chronic inflammatory state has led to a special modification in the dense connective tissue.

CHOICE OF TREATMENT

These facts explain why the undifferentiated cancers composed of cells which are young, wandering, and highly fragile in the presence of external agents, disappear promptly under the influence of radiation regardless of their size; whereas, cancers composed of differentiated cells, which exhibit more mature evolution without great movability and remain close to their source of origin, behave differently.

The tendency of differentiated cells to live together in a group and to be intimately associated with muscle distinguishes them from undifferentiated cells which conserve their complete independence in relation to the tumor bed in which they live. Muscle infiltration is a peculiar and characteristic feature of differentiated cells which results not only in the muscle becoming rapidly immobilized but also in an intimate association of the neoplastic cells and muscle fibers which it is impossible to separate. In this process the neoplastic cells appear to receive their nourishment from the muscle fibers which slowly lose their biological properties, leading to a replacement of the muscle fibers by fibrosclerotic tissue. Under these circumstances the disappearance of differentiated neoplastic cells under the influence of radiation is almost impossible.

If one succeeds in sterilizing a lesion of this type by means of x-rays, a result which is very rare, there always develops a necrotic destruction of the treated area either immediately or after 3 months, 6 months, or 1 year. Examples of this type of lesion are highly differentiated and infiltrating cancers of the vocal cord, differentiated cancers of the anterosuperior part of the tongue, and cancers of the anterior part of the pillar, which are composed of differentiated cells. Sterilization of the tumor with conservation of the tissues of the tumor bed under these conditions is not possible. The union of the neoplastic cells and surrounding normal cells has been too intimate. Necrosis of the anterosuperior portion of the tongue following sterilization of the epithelioma is of no great significance, but necrosis of the tissues occupied by the neoplasm at the level of the larynx, even with complete disappearance of the cancer, always results in death if there has not been a previous tracheotomy, and sometimes provokes bronchopneumonia even with a previous tracheotomy. The elimination of the necrotic

From the Chicago Tumor Institute.
Presented in the Symposium on Cancer, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

portion, which may be soft or cartilaginous, requires too great an effort on the part of the tissues and organism and is sometimes prolonged for as much as 2 years before elimination and repair are complete. The treatment of differentiated cancer of the larynx which infiltrates and immobilizes the underlying muscle belongs, therefore, to the domain of surgery rather than to that of radiology.

In summary, differentiated cancers of the larynx which are technically operable belong to the domain of surgery if the hemilarynx is completely fixed. It is only when the immobilization is incomplete that this type of cancer can be cured by irradiation.

Cancers composed of undifferentiated cells are easily modified by radiation regardless of whether they are small or large, operable or inoperable. This variety of cancer is best treated by radiation. In this type, regardless of the degree of development, the invaded parts remain slightly movable and the lesion disappears without apparent modification of the connective tissue in which it has developed. Because of their tendency to cellular dissemination, the undifferentiated cancers are never biologically operable even though they are technically operable. Surgical intervention increases the danger of dissemination. We might emphasize the danger of surgical intervention in this type even when the surgical procedure is adequate by demonstrating a large number of cancers of the larynx, pharynx, oral cavity, and breast, but we think that these facts are already so well known that this is not necessary.

METHOD OF ROENTGEN THERAPY

Following are the methods of x-ray treatment in brief, for it is a subject which is only of limited interest:

Cellulicidal technique—radio-epithelite, radio-epidermite. The treatments which have been used until now have had for their aim the destruction of neoplastic cells, that is to say, a cellulicidal technique. After some days of treatment, the cells are covered by a false membrane when the cancer is composed of undifferentiated cells. Depending upon the degree of differentiation, these false membranes appear between the fifth and thirteenth days after the beginning of treatment. On the thirteenth day the false membrane appears on the normal mucous membranes (radio-epithelite). When a cancer is composed of cells which are more fragile than those of the normal epithelium of the mucous membrane the false neoplastic membrane appears before the false membrane of the normal mucous membrane. If the neoplastic cells do not show a false membrane until the sixteenth or seventeenth day or later, it is because they are less sensitive than the normal cells of the mucous membrane. Under these conditions we are dealing with a cancer whose cells are more differentiated. If no cellular modification or diminution in size appears before the twenty-fifth day, it is because the sensitivity of the cells is in the neighborhood of those of the cutaneous cells which are destroyed only between the twenty-sixth and twenty-eighth days (radio-epidermite).

This information is valuable for cancers which are not infiltrating, that is to say, those which have respected the muscle. As soon as the cells have invaded the muscle, the cellulicidal method is, as we have already said, not effective because it is unable to yield any rational cure, that is, sterilization of the cancer with conservation of the normal tissues. Consequently, we shall discuss here only the cellulicidal technique as it is applied to undifferentiated or slightly differentiated cancers which have not infiltrated the underlying muscle. This technique may be applied in several ways.

Daily and continuous treatment. The roentgen therapy of cancer of the larynx gives us results only when we distribute in the larynx through two lateral fields 50 centimeters square, a total dose of 7,000 r, that is, about 5,000 r to the side of the lesion and 2,000 r to the opposite side, measured on the skin. This daily continuous treatment is distributed as follows: in 20 to 25 days for cancers composed of slightly differentiated cells; in 15 days at a maximum for cancers composed of very differentiated cells; and in 40 days for cancers which are completely undifferentiated. There is a tendency now to reduce this time.

Preparatory treatment. If the cancer is very extensive and very infected, and the general state of the patient is bad, we precede the main treatment by a preparation lasting for 13 to 26 days, without interruption between the two varieties of treatment. The fields are increased on the surface, reaching 100 square centimeters and administering between 5 and 50 r, according to the voltages and according to the thickness of the tissues. The aim of these irradiations is not to act on the neoplastic cells whose cellulicidal threshold never appears below a daily dose of 150 r, but to reduce the infection and to improve the connective vascular tissue. It is, therefore, necessary to diminish as much as possible the daily dose in order to avoid the development by the rays of fibrosclerotic connective tissue, a transformation which reduces the sensitivity of

the cells. This method was used for all the cancers of the larynx in 1932 and seems to us to be the cause of improvement in 5 year results.

Periodic treatment. We have also studied the effects of periodic treatment in the differentiated forms of cancer. Non-continuous treatment in 2 or 3 periods, distributed in such a manner that the moment of cellulicidal effect coincides with the moment of sensitivity of the normal epithelium of the mucous membrane, which appears on the thirteenth, twenty-sixth or thirty-ninth days. This coincidence is possible only if the daily dose largely surpasses the cellulicidal threshold of the differentiated neoplastic cells, which is rarely less than 400 r. This treatment constitutes the only method which has given us any results for cancer of differentiated cells.

Palliative treatment. In cases not successfully treated by radiation, as for example in the case of a recurrence, and in cases in which it is impossible to administer efficacious treatment by radiation on account of marked cachexia, all varieties of treatment known as palliative treatment simulate the type of treatment which has been described as *preparatory*, but with still weaker daily doses, or 5 to 25 r, and with an aim only to modify favorably the vasculoconnective tissue.

ASSOCIATION OF SURGERY AND ROENTGEN THERAPY

The combination of surgery and x-rays in the treatment of inoperable cancer of the larynx has not yielded any better results than those obtained by surgery alone or by x-rays alone. In the treatment of postoperative recurrence, non-sterilization after x-ray therapy is often associated with necrosis at the site of the operative scar. This necrosis has sometimes resulted in a large fistulous tract extending from the larynx into the skin. On the other hand, when a surgical operation is performed upon a recurrence following irradiation, radionecrosis of the soft parts and cartilage is frequently produced.

These complications are due largely to the fact that the combination of irradiation and surgery is utilized as a result of urgent necessity rather than a careful and deliberate study of the problem before treatment is instituted.

Let us consider two groups of cases in which the association of these two therapeutic agents is carefully studied before treatment is begun.

1. In the management of differentiated carcinomas which infiltrate the muscle and which are inoperable without being too extensive, it is sometimes useful, after tracheotomy, to perform an intentionally incomplete operation in order to conserve the greater part of the larynx. This operation, the aim of which is to remove the most radioresistant portions of the lesion, is followed as soon as possible by complete irradiation. This irradiation should be administered before there has been a chance for fibrosclerosis to develop. During the time immediately after operation, there exists a type of postoperative cellular activity which renders the tumor cells more radiosensitive. When this type of cancer, which is composed of differentiated cells, has destroyed the muscle and cartilage, the operation serves to eliminate the infected and necrotic tissues.

2. In the management of carcinomas composed of undifferentiated cells the following procedure is adopted. If one chooses to treat this form of cancer surgically, it is wise to precede the operation by comparatively small doses of x-rays, that is to say, 3000 r units administered in 10 to 12 days. A daily dose of 250 to 300 r units will suffice to cause the disappearance of the most fragile cells which are the most dangerous elements from the point of view of postoperative dissemination. The surgical operation should follow the irradiation by about 17 days at the latest after the first x-ray treatment.

For the reasons which have been discussed, it is necessary that the therapeutic procedures in both circumstances be grouped as closely as possible in order that the second treatment receive the greatest benefit from the first.

RESULTS

General results. As to patients treated in our service in the Curie Foundation in 1921 to 1932 for inoperable cancer of the larynx or for postoperative recurrence, out of a period of 12 years of treatment, 3 years only yielded good results. They are 1921, 1926, and 1932, with 50, 52, and 66 per cent 5 year survivals and free of disease. The other years are bad or mediocre. The general average for 5 year survivals is only 39 of 142 patients or 27 per cent. The study of all these cases has established that cancers composed of undifferentiated cells were very numerous in the 3 favorable years, and that cancers composed of differentiated cells were very numerous in the course of the bad years. This accounts in part for the inequality of the results, but in fact our inadequate knowledge of the effects of radiation on cancer, very dissimilar from the point of view of cellular differentiation, muscle invasion, invasion of cartilage, and musculocartilaginous necrosis, explains that our technique was sometimes efficacious and sometimes not. In an effort to correct the dissimilarity in results, we have

been obliged to test every kind of treatment. These changes in technique have sometimes appeared contradictory.

The factors just mentioned partly explain the results during a course of successive years. The best year, 1921, was followed by the worst year, 1922, since in the latter we did not have a single 5 year cure out of 11 patients treated.

Likewise, after 1926 we had a series of mediocre years, 14 and 16 per cent in 1929 and 1930, respectively, are the worst results after 1926. In 1931, there were 28 per cent. The results attain their maximum in 1932 after which the percentage will probably go down again.

During the course of these 12 years, the duration of treatment was sometimes long and sometimes short. The treatment periods have varied from 10 to 50 days, the daily dose between 200 r and 800 r measured on the skin, the fields between 40 and 150 centimeters square. In spite of these variations the total dose which caused the disappearance of cancer of the larynx remained in the neighborhood of 7000 r.

CRITICAL PERIOD AFTER FIVE YEAR SURVIVALS

Among the 8 patients treated in 1921, 4 reached the 5 year survival period without signs of cancer; they are still free of disease after 10 and 15 years.

The patients treated in 1926 and 1932 reached a 5 year survival in a higher proportion, that is 9 out of 17, or 52 per cent, and 6 out of 9, or 66 per cent, but the results after 5 years are inferior to those of 1921.

Among the 17 patients treated in 1926, of which 9 reached the 5 year period with freedom from symptoms, 4 subsequently died; 3 died of new cancerous manifestations of the larynx; 1 during the course of the sixth year, and 2 during the course of the eighth year. The fourth patient died at the advanced age of 79 years during the course of the ninth year without apparent recurrence. Thus there are 3 deaths with new cancerous manifestations between the sixth and the eighth years, that is, 3 out of 9, or 33 per cent of the patients who survived 5 years. These manifestations appeared in the 3 cases at the end of the sixth year. The number of patients surviving without symptoms remains the same, 9 at 12 years after treatment.

Among the 9 patients treated in 1932, 6 have reached the 5 year period without symptoms. Of these 6, 2 have died during the course of the sixth year of new cancerous manifestations; 1 case was a postoperative recurrence.

In summary, of 15 patients remaining free of disease for 5 years, 5 or 33 per cent have developed a new cancerous manifestation during the sixth year. Thus it seems that about the end of the sixth year, there appear special phenomena which are able to provoke the appearance of new cancerous manifestations.

Certainly the number of cases of cancer of the larynx observed is not large. We should not be permitted to speak of these facts if we had not seen similar phenomena in other locations. In our cases of cancer of the oral cavity and of the tonsil in particular, when a patient presented a new cancerous manifestation death occurred between the sixth and eighth years. The new cancerous manifestations seem to begin about the end of the sixth year, and the patients who escape this manifestation remain without symptoms for 10 to 15 years.

In the treatment of undifferentiated carcinomas which are apparently cured, there seems to exist a critical period appearing about 6 years after the irradiation. This critical period causes death 1, 2, or 3 years later, and if the patient escapes this critical period the cure appears to be definite.

The question arises as to whether this period is the same in other types of tumors. We are completely ignorant of this. Although we have observed this in adenocarcinoma of the breast composed of undifferentiated cells, still in general the number of these cases of 5 year survivals is too small. The statistics of the Registry of Bone Sarcoma of the American College of Surgeons shows that of 112 cases of bone sarcoma living and clinically free of disease for a period of 5 years or more following treatment by surgery or by irradiation, 6 patients died of cancer after 5 years, of which 3 died of metastasis during the course of the eighth year.

ONE OF THE CAUSES OF THE APPEARANCE OF THE CRITICAL PERIOD

The changes in the methods of treatment which we have considered in their time as improvements did not always constitute real improvements; or more precisely, we now see the advantages and disadvantages of the different methods utilized.

This is especially true of the methods applied in 1926 and 1932, which have given us results that seem superior to those of 1921. This improvement in results was apparent and not real. Certainly the percentage of 5 year survivals without symptoms has increased, but this increase, as we have said, is compensated by the lowering of the duration of the survivals, since the results of 1926 and 1932 fall during the course of the critical period from 52 and 66 per cent to 35 and 44 per cent.

The disappearance of all the neoplastic cells in the cases of 5 year survivals has been obtained regardless of whether the treatments were long or short. However, when the daily doses have not reached a certain minimum threshold, particularly during the course of the last days of irradiation, the critical period has appeared; and this would suggest that after the disappearance of the neoplastic cells, special elements remained which were not modified by the treatment. We find the same effect in other locations.

What are these special elements? Are they cellular? Are they composed of a special group of invisible mother cells, hidden in a sclerotic vasculoconnective tissue such as one sees in cancer of the breast in which new cancerous manifestations seem to appear at every period after 5 years? This is only remotely probable since the moment of the cancerous manifestations seems fixed, 6 years.

On the contrary, are they formed of a substance having cellulomitogenic properties or a carcinogenic substance whose cancerization effect appears after 6 years? We should be obliged to admit it if the moment of the critical period were the same for all varieties of cancer.

Regardless of the theoretical considerations which these facts suggest, they bring to us for the moment useful indications for radiation technique which may permit us to escape the critical period and avoid recurrence. These facts teach us especially that for the same total dose we must reach a high threshold during the course of the final daily treatments, a threshold sometimes greater than 800 r. On the contrary, under certain conditions, daily doses of 5 r preceding the cellulocidal treatment appear efficacious by a process of which we are totally ignorant. This possibility of utilizing extreme variations in the daily doses and in their effects in roentgen therapy is a fact not only very curious but encouraging for the future.

SUMMARY

Clinically and histologically there exist two main varieties of laryngeal cancer: cancers composed of undifferentiated cells having a great tendency to early and widespread dissemination in the loose vasculoconnective tissue, and cancer composed of differentiated cells having a special affinity for the muscles and an immobilization of muscle without any tendency to dissemination.

Cancers composed of undifferentiated cells are treated successfully and easily by x-rays. Because of their tendency to dissemination, they are not biologically operable, even though they are technically operable.

Cancers composed of differentiated cells are in the domain of surgery, and usually are not curable by radiation because of the intimate connection between muscle cells and carcinoma cells.

Treatment of inoperable cancers by x-rays which we have used are: (1) preparatory treatment; (2) daily and continuous treatment; and (3) periodic treatment.

The preparatory treatment has increased the number of 5 year survivals, but the insufficient daily doses during the last 3 days of treatment has provoked sometimes the appearance of a recurrence about 6 years after irradiation. This seems to be the critical period, and death occurs 1, 2 or 3 years later. If the patients escape this critical period, they are still free of disease after 15 years. The possibility of utilizing extreme variations in the daily doses, very small or 5 r in the preparatory treatment, and very high, or 900 r during the last day of the continuous treatment, is very encouraging for the future.

OBSTETRICS AND GYNECOLOGY

ESTROGENIC HORMONES AND CARCINOGENESIS

LUDWIG A. EMGE, M.D., San Francisco, California

As far as is known, the highest cancer incidence in the mammalian world is found in mice. This is particularly true of mammary cancer which, in certain strains, may affect 100 per cent of the females and, if they receive estrogen[1] artificially, a high percentage of the males. Because of this latter occurrence, it has been concluded that estrogen possesses cancer-provoking properties. It is the purpose of this paper to discuss certain pertinent factors and present further experimental studies regarding the relation of estrogen to neoplasia. The voluminous literature dealing with this subject has been reviewed recently by Taylor, Jr. and is therefore omitted here.

The fact that a substance manufactured in a mammalian body for the maintenance of normal functions can, under certain circumstances, provoke cancer in an organ normally stimulated by it is unquestionably important and deserves careful consideration of its true significance. There can be no doubt that cancer of the breasts of mice, provided this tissue has been hereditarily destined to develop cancer, is dependent on the presence of estrogen (18). Comparative studies indicate that the factor of prime importance in this mechanism is not so much *estrogen* as it is *hereditary susceptibility*. Mice, as mentioned, show a particularly high tendency to mammary cancer. Rats, on the other hand, possess an equally great immunity to this form of cancer, although they are subject to mammary adenofibromas which have shown malignant potentialities in transplantation (5, 13, 14). This evident difference in species susceptibility strongly suggests that the rôle of estrogen in carcinogenesis is limited by certain biological patterns.

The huge mass of information on carcinogenesis which has been accumulating for a period of years indicates that cancer is not a single disease but a group of diseases, the common aspect of which is the destruction of life. More and more evidence is forthcoming to show that the provocative causes vary with different types of cancer, and probably vary in their specificity in different species. On purely experimental evidence, it is possible to divide these causes into two, or possibly three, groups (Fig. 1). One produces neoplasia at the site of first contact, such as tar, benzanthracene derivatives, and certain parasites, and is therefore truly *carcinogenic*. The other incites distant cells to assume a malignant behavior without necessarily producing neoplasia at the site of application, which might be called *carcinotropic*. Estrogen and certain viruses possess this faculty. The third, an undefinable factor, may possess both faculties and would cover the still unexplained cancer-provoking action of certain rays. Provocative factors are modified by age and sex, and probably by vitamins and enzymes, although this is not readily demonstrated. However, it has been shown that vitamin-A deficiencies favor metaplasia according to McCullough and Dalldorf, and enzymes normally necessary for certain cell metabolism disappear with malignant degeneration.

Carcinogenic impulses are either favored or neutralized by a group of hereditary factors. General susceptibility or immunity to malignant neoplasia dominates all other hereditary factors such as species, strain, organ, and cell differentials which exert a modifying influence in a more specialized sense. Their importance is demonstrated in the oft-cited classical experiment of Fibiger on gastric cancer in rats, which proved that it required a specific susceptible host, a specific transmitting vehicle, and a specific cancer provocative to produce cancer in a specific cell of a specific organ.

The mechanism of transmission of hereditary factors is still in dispute. Based on breeding experiments on mice, Little considers this essentially a non-Mendelian mechanism following maternal lines and indicating that the cytoplasm of the egg can transmit characteristics independent of

From the Department of Obstetrics and Gynecology, Stanford University School of Medicine.

Presented in the Symposium on Obstetrics and Gynecology before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

[1] The terms *estrogen* and *estrogenic* are used here for all substances having estrus-producing properties, as suggested by the Council of Pharm. and Chem. of the A. M. A. in Vol. 107, page 1221, 1936.

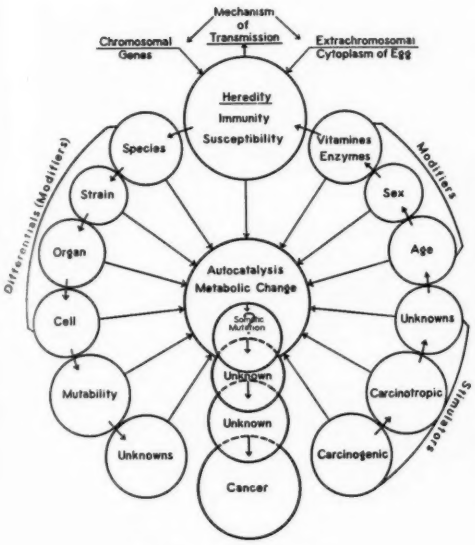


Fig. 1. Causes of cancer.

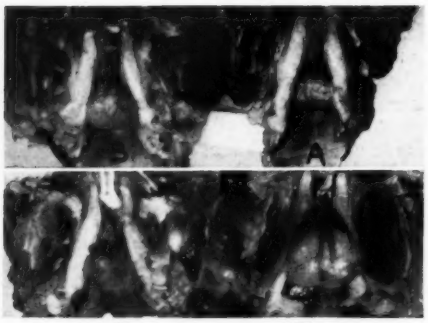
chromosomes. This is quite in opposition to Slye's deductions, which favor chromosomal transmission according to Mendelian laws.

The mutability of cells, i.e., the faculty to change either the physical or functional characteristics, is still an unknown factor. However, since tissues subject to frequent cyclic and regenerative changes often exhibit unusual cataplastic and metaplastic tendencies, mutability may be a factor in carcinogenesis. The existence of other factors not yet demonstrated is taken for granted and grouped under "unknowns." No attempt is made here to explain the mechanism which brings all factors together, which Loeb calls "autocatalysis," i.e., something that generates from within.

The action of estrogenic hormones in relation to mammary cancer in mice conforms remarkably well with the scheme just outlined. Briefly, these hormones incite distant cells (mammary) to undergo malignant degeneration *when hereditarily prepared*, and ordinarily do not produce neoplasia at the site of application. Age and sex modify their action in varying degrees according to Loeb (17), Cori, and Murray. When mammary tissue is not susceptible to cancer it responds to estrogenic stimuli by orderly proliferation which, although extensive, remains definitely limited by physiological capacity.

The secondary modifying factors show themselves in various ways. Thus, duct cells respond far more readily than acinar cells to the carcinotropic influence of estrogen. The importance of the organ differential is expressed by the failure of estrogen to precipitate a malignant reaction in other organs hereditarily destined to develop cancer. Strain differentials are shown by the complete lack of malignant response in breast tissue of certain strains of mice, and species differences are evident from comparative studies of

Fig. 2. Chart showing gains in weight. *1*, 100 day females unimplanted and untreated; *2*, 100 day females unimplanted and treated with theelin in oil 100 international units weekly; *3*, 100 day females implanted and untreated; *4*, 100 day females implanted and treated with theelin in oil 100 international units weekly; *5*, 100 day females implanted and treated with oil 0.1 cubic centimeter weekly; *6*, 100 day females implanted and treated with theelin in oil 1,000 international units daily.



C D

Fig. 3. A, Normal; B, 66,000 international units of theelin in 77 days; C, 1300 international units of theelin in 85 days; D, 78,000 international units of theelin in 91 days.

mice, rats, and rabbits. The results of certain experiments, attempting through superphysiological stimulation with estrogen to incite the epithelium of the genital tract to uncontrolled hyperplasia, further demonstrate the modifying action of differentials. In mice treated over periods of time with relatively large doses, Gardner, Allen, Smith and Strong, and Suntzeff, Burns, Moskop, and Loeb observed occasional cancer-like proliferations in the vagina and uterus in a few animals. Overholser and Allen observed a cancer-like lesion on the cervix of 1 monkey in a group treated with theelin and local traumatization. Others (10, 15, 19, 20, 21), studying rats and monkeys under increased estrogen loads, obtained only metaplasias. The difference in end-results probably is not due to variations in the estrogenic stimulation but rather to the result of variations in receptiveness of the genital tissues. Compared with mammary cancer, the yield of genital cancer, even in susceptible mice, is insignificant. This is in line with the assumption that the relation of estrogen to tissue proliferation depends on biological patterns. The experiments of Perry and Ginzton point in the same direction. These investigators found that in mice of an unpedigreed stock and of unknown origin the combination of 1:2:5:6 dibenzanthracene with theelin yielded a greater number of tumors than dibenzanthracene alone.

Assuming that tissue proliferation produced by estrogen conforms to hereditary biological patterns, we have attempted for some time to determine this pattern in a strain of rats entirely refractory to cancer. This strain came originally from a Wistar strain of the University of Chicago, which had been bred at Stanford University since 1903, and studied in our laboratory since 1928. Breeding females occasionally produce a benign mammary adenofibroma readily transplantable but subject to sarcomatous degeneration (Emge, 5). Although we have transplanted these tumors for nearly 10 years, we have never encountered a carcinomatous degeneration. Since they respond to hormonal stimulation as well as normal breast tissue (Emge and Wulff, 9), it occurred to us that if we could maintain a constant state of lactation it might be possible to invite not only a progressive proliferation of the epithelium but an unusual storage of secretion which, according to Bogen, is a factor in mammary cancer in certain mice. In order to produce this state we destroyed the litters of breeding females implanted with mammary adenofibromas, at birth, and immediately bred them again. By this means it was possible to achieve an almost constant state of pregnancy, resulting in immense hyperplasia of tumor and breast tissue (Emge and Murphy, 7). Although the storage of milk assumed relatively great proportions, particularly in the tumors, no malignant changes

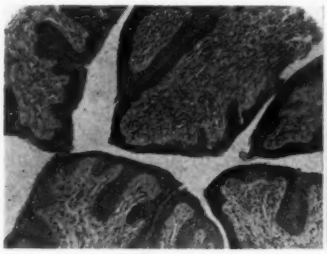


Fig. 4.

Fig. 5.

Fig. 4. Vagina normal.
Fig. 5. Vagina after 12,000 international units of theelin in 14 days; intracellular edema.

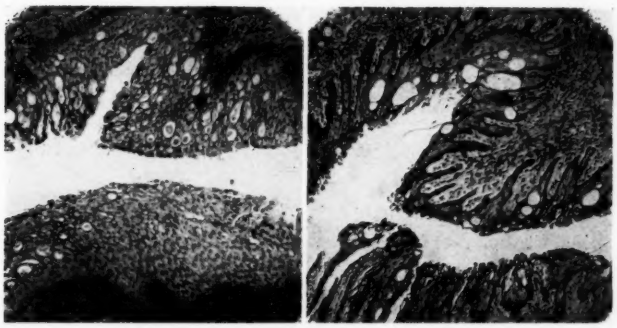


Fig. 6. Fig. 7.

Fig. 6. Vagina and cervix after 28,000 international units of theelin in 32 days; vacuolization.

Fig. 7. Vagina and cervix after 29,000 international units of theelin in 34 days; epithelium down-growth.

were observed. With the subsidence of the pregnant state, involution proceeded at a normal rate in the breasts but was considerably slower in the adenofibromas. Animals observed over long periods showed no latent changes in either tumors or breasts. This is not different from the behavior of adenofibromas of the human breast, which involute after lactation at a slower rate than the normal breast tissue. Failure to produce abnormal cell proliferation in adenofibromas storing massive quantities of secretion speaks against retention as a factor in carcinogenesis in this strain of rats.

Having failed to produce abnormal cell proliferation by unusually prolonged spontaneous stimulation, we (8) resorted to the administration of aqueous theelin. Doses approximating or exceeding ordinary physiological requirements were given over long periods to male and female rats again implanted with mammary adenofibroma. The outstanding result was a fibrosis of the transplanted adenofibroma, a decrease in glandular components with an occasional hyperplasia of the ducts, and a slight proliferation of the same structures in the normal breast tissue *in situ*. We noticed that animals receiving twice the dosage of others produced slightly more epithelial proliferation in both tumor and normal breast epithelium. However, the difference did not warrant the conclusion that the action of the hormone was quantitative. In another experiment, smaller though physiologically excessive doses of theelin were given for longer periods, and we observed still more fibrosis in similar tumors and practically no changes in the normal breast tissue. However, in this experiment 1 tumor was found to have developed a tremendous cystic mastoplasia, which emphasizes the fact that

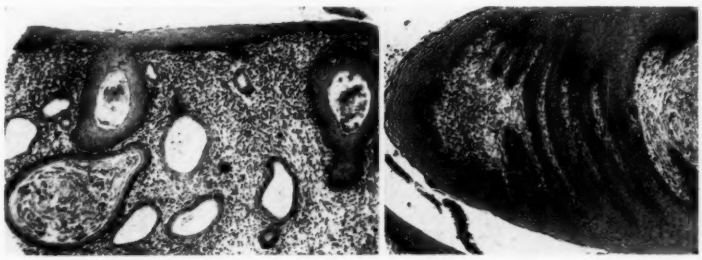


Fig. 8. Fig. 9.

Fig. 8. Cervical canal after 44,000 international units of theelin in 50 days; metaplasia of isthmic glands.

Fig. 9. Part of cervix after 53,000 international units of theelin in 62 days; epithelial hyperplasia.

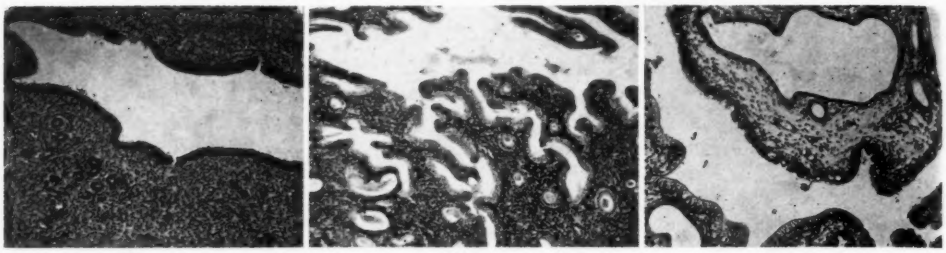


Fig. 10. Fig. 11. Fig. 12.

Fig. 10. Endometrium after 800 international units of theelin in 50 days; practically unchanged.

Fig. 11. Endometrium after 12,000 international units of theelin in 14 days; polypoid hyperplasia.

Fig. 12. Endometrium after 28,000 international units of theelin in 32 days; cystic hyperplasia.

qualitative and quantitative differences to estrogen stimulation exist in morphologically similar tissues (Emge and Murphy, 6).

We are now investigating this question in a series of experiments, to be reported in detail at a later date. In the present study, rats 168 days old received 50 international units of aqueous theelin bi-weekly for from 20 to 34 weeks. Breast changes were moderate, with the usual slight proliferation of duct tissue, but the difference between 20 and 34 weeks of treatment was not very remarkable. In the genital tract, however, the response of all epitheliums was distinctly different for the 2 periods, the longer treatment producing a more massive cornification of the squamous epithelium and a more definite increase in the size of the endometrial glands. Allowing for a possible difference in the effect of the time element on different organs, the action of theelin was less quantitative on the breast tissue than on the genital tract.

In order to further clarify this point we are now observing the results of theelin in oil given in doses varying from 100 international units weekly to 1,000 international units daily to a large group of female rats of different ages implanted with a very glandular adenofibroma. Breast tissue is being removed sufficiently often to obtain information about the progressive action of the hormone. The animals are disposed of at various periods of the experiment and their genital tracts studied *in toto*. *We appreciate that the large doses employed are out of all proportion to physiological requirements and do not parallel therapeutic practice.* However, having found previously that doses within physiological limits, regardless of the length of time of administration, did not create spectacular changes, we felt that we should go the limit in dosage in order to learn if there was any dose which might incite malignant proliferation. We felt that by *pushing* the dosage we might have a better chance to ascertain limits of immediate response as a basis for quantitative differences. The state of this experiment justifies only the presentation of preliminary observations.

Doses of theelin as great as 1,000 international units daily produce definite physiological changes in our rats within 10 to 14 days. The weight gain stops abruptly, as demonstrated in Figure 2 for young animals; the hair of the older rats becomes

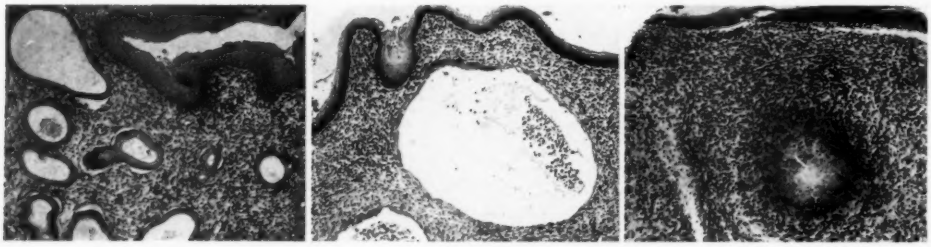


Fig. 13. Fig. 14. Fig. 15.

Fig. 13. Endometrium after 44,000 international units of theelin in 50 days; metaplasia.

Fig. 14. Endometrium after 53,000 international units of theelin in 62 days; destructive stage.

Fig. 15. Endometrium after 53,000 international units of theelin in 62 days; destructive stage.

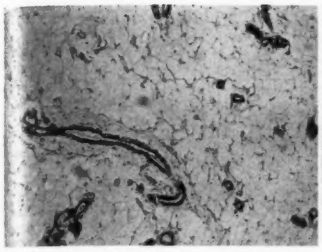


Fig. 16.

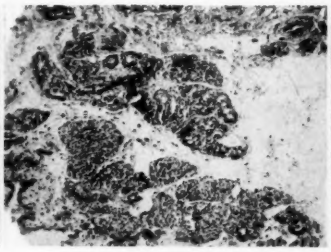


Fig. 17.

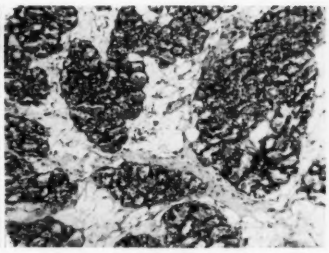


Fig. 18.

Fig. 16. Breast after 500 international units of theelin in 31 days; practically unchanged.

Fig. 17. Breast after 12,000 international units of theelin had been given in 14 days; early hyperplasia.

Fig. 18. Breast after 28,000 international units of theelin in 32 days; hyperplasia, stage of secretion.

seedy and the tips of the hair turn brown. Soon the animals refuse to eat and would eventually die if we did not forestall this by selective destruction. Within each group of animals there are individual differences in tolerance, most marked in the older groups. We found that theelin has a lethal limit which, in older animals, approximates 60,000 to 70,000 international units in 64 to 71 days. Younger animals are more tolerant to large doses. Since the injection of oil alone, used as a vehicle for theelin, produces none of these reactions, it must be assumed that theelin alone is responsible. We presume that this is not a direct action of theelin but an indirect result of profound changes in the endocrine system, particularly marked in the pituitary and adrenal glands (3, 4, 28). This is well in line with weight disturbances and atrophy of the ovaries common in the animals studied by us. The hypophysis enlarges rapidly under the influence of large doses and ultimately goes on to adenomatous degeneration. Smaller doses will yield the same result if given sufficiently long as demonstrated in Figure 3. Zondek recently reported that the formation of pituitary adenomas in female rats required about 8 months of treatment with fairly large doses of estrogen. We obtained the same result with larger doses in 70 days. This, again, speaks for quantitative differences in the action of estrogen.

The changes observed in the genital tract during estrogen stimulation also indicate a quantitative response. In 400 day old rats, one receiving 800 international units in 50 days (Fig. 10) reacts much less drastically than 1 receiving 12,000 international units in 14 days (Fig. 11), and even still less than 1 receiving 44,000 international units in 50 days (Fig. 13). The degree of response of the genital epithelium, therefore, depends not only upon dosage but upon the frequency of administration. These changes in the cervix and vagina (Figs. 4, 5, 6, 7, 8, 9) begin with a persistent cornification of the surface epithelium similar to estrus, but more pronounced. This is followed by increased activity and multiplication of cells resulting not only in a thickening of the surface epithelium but in a downward extension of epithelial columns. At the same time, the sharp demarcation between cervical and endometrial epithelium disappears and endometrial glands begin to proliferate. As the estrogen load

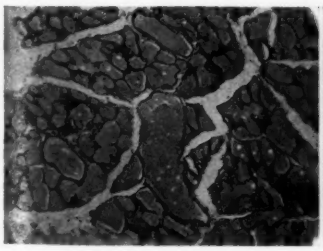


Fig. 19.

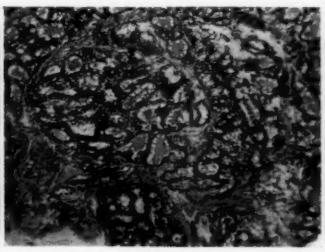


Fig. 20.

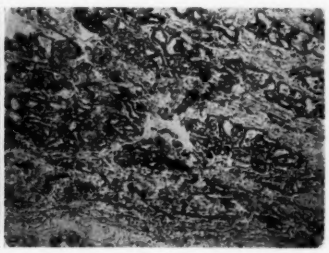


Fig. 21.

Fig. 19. Breast after 29,000 international units of theelin in 34 days; early cyst formation.

Fig. 20. Breast after 45,000 international units of theelin in 51 days; vacuolization.

Fig. 21. Breast after 53,000 international units of theelin in 62 days; physiological fatigue and fibrosis.

Fig. 22.

Fig. 23.

Fig. 24.

Fig. 22. Adenofibroma donor, untreated.
Fig. 23. Adenofibroma after 28,000 international units of theelin in 32 days; hyperplasia.

Fig. 24. Adenofibroma after the administration of 29,000 international units of theelin in 34 days; cystic hyperplasia.

is increased, the stratified epithelium of the vagina and cervix becomes edematous and widespread vacuolization takes place. The endometrium has by now progressed to a state of hyperplasia which suggests polyp formation. The glands are greatly dilated and filled with secretion. Metaplasia of the endometrium next occurs near the cervical junction. At first, only isthmic glands are affected, the endometrial glands having assumed a degree of dilatation very similar in appearance to that seen in functional hyperplasia of the endometrium in man (Figs. 10, 11, 12). Progressive metaplasia of the entire epithelial lining of the uterus, which ultimately involves the endometrial glands, marks the height of the reaction (Fig. 13). At this point the limit of physiological response is reached and cellular exhaustion is expressed by extensive shedding of the surface layer and the accumulation of polymorphonuclear leucocytes in the uterine cavity as well as in the glands (Figs. 14, 15). Sterile pyometra invariably marks the end-phase of the response of the genital tract in this strain of rats. It may be assumed, therefore, that in the absence of hereditary susceptibility to cancer the physiological pattern, typical for the behavior of the genital tract of these rats, determines the extent and severity of the cellular response, *beyond which no amount of stimulation will produce further hyper- or metaplasia*. This mechanism would seem to be equally important as that responsible for mammary cancer in mice hereditarily destined to develop cancer.

The quantitative differences in response to estrogen are further demonstrated in a comparison of breast tissue *in situ* with implanted mammary adenofibroma removed at different periods of treatment. Here, also, a biological pattern seems to determine the ability of these tissues to respond to various estrogen loads, although not as dramatically as in the genital tract. In both the normal (Figs. 16, 17, 18, 19, 20, 21), and the tumor tissues (Figs. 22, 23, 24, 25, 26), the height of the secretory response occurs at about 45,000 international units given in 45 days. The various stages of secretory response begin with a simple proliferation of the ducts, followed by lobulation. Acini proliferate next and secretion appears. With further proliferation distention of alveoli and ducts, due to the accumulation of secretion, becomes evident and cyst formation results. This

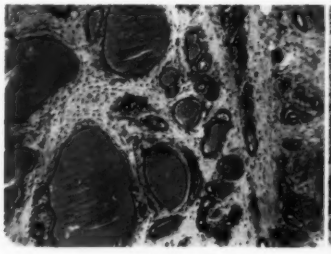


Fig. 25.

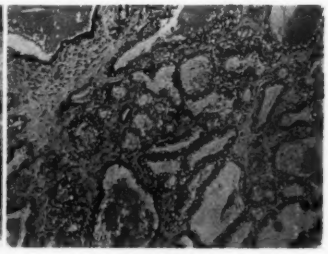


Fig. 26.

Fig. 25. Adenofibroma after 45,000 international units of theelin in 51 days; cystic mastoplasia.
Fig. 26. Adenofibroma after 53,000 international units of theelin in 62 days; exhaustive stage.

is more pronounced in the tumors (Fig. 24) than in breasts *in situ* (Fig. 19), and is probably due to a greater storage of secretion. Cyst formation is followed by fibrosis, again more marked in the adenofibromas, which have a greater abundance of stroma (Figs. 20, 25). Vacuolization of the glandular components precedes minor degrees of metaplasia, which marks the beginning of the end-phase of physiological response. In the breast tissue a slow breaking-down of glandular epithelium marks the lack of further proliferative ability. As far as we have been able to learn, the end-phase of secretory response in the adenofibromas is of a similar nature, but the limited tolerance of the host to large doses of theelin has not permitted us to determine this accurately. As yet, we have not encountered stromal or epithelial changes which would indicate that theelin in oil can incite malignant changes either in the normal breast tissue or in the implanted adenofibromas in this strain of rats. This, in a general way, corresponds with the behavior of the epithelium of the genital tract and confirms the assumption that estrogen, even in extreme doses in a breed of animals protected by an inherent immunity, does not incite malignancy in tissue it normally stimulates.

SUMMARY

In a series of experiments on white rats of different ages, in which the dosage of aqueous theelin and theelin in oil were administered in varying dosages and over varying periods of time, no malignant changes were produced in the mammary glands, in the genital tract, or in transplanted mammary adenofibromas. Since this strain of rats is entirely free from spontaneous cancer, it is assumed that a hereditary immunity protects breast and genital tissue against excessive and uncontrolled proliferation regardless of massive doses of estrogen. The proliferative changes observed are quantitative and self-limited, and probably do not occur spontaneously even under high physiological loads of estrogen, as observed in pregnancy experiments. A maximal response to estrogenic stimulation is terminated by a process of cell exhaustion and cell destruction, probably dependent upon changes in the hypophysis due to superphysiological stimulation by estrogen.

Evidence is accumulating to prove that the action of the estrogenic hormones is controlled by definite biological patterns, and that their cancer-provoking faculty in small laboratory animals is strictly limited by hereditary tendencies. There also is evidence that the effect of estrogen on mammary and genital epitheliums is essentially quantitative. It is again emphasized that the tremendous dosage used in certain of these experiments does not parallel spontaneous physiological processes and far exceeds any clinical usage.

After 2 years of observation on the effects of estrogen stimulation of breast and genital tissue in a strain of white rats free from spontaneous cancer, we have come to believe that the carcinogenic effect of this hormone must be extremely limited. We are not convinced, because estrogen favors spontaneous mammary cancer in mice highly susceptible to this malignancy, that other species of mammalia are likewise affected.

This research has been supported in part by the Memorial Fund for Cancer Research and the Rockefeller Fluid Research Fund of Stanford University.

The theelin used in these experiments was generously donated by Parke, Davis and Co. through the courtesy of Dr. E. A. Sharp.

The assistance of Dr. G. L. Laqueur, L. M. R. Wulff, and Pierre Lassegues is gratefully acknowledged.

BIBLIOGRAPHY

1. Bogen, E. The cause of breast cancer. Am. J. Pub. Health, 1935, 25: 245.
2. Cori, C. F. The influence of ovariectomy on the occurrence of mammary carcinoma in mice. J. Exper. Med., 1927, 45: 983.
3. Cramer, W., and Horning, E. S. Adrenal changes associated with estrin administration and mammary cancer. J. of Path. & Bacteriol., 1937, 44: 633.
4. Diaz, J. T., Phelps, D., Ellison, E. T., and Burch, J. C. The effects of various gonadotropic substances upon the ovaries, pituitaries, and adrenals of animals receiving long-term injections of estrin. Am. J. Physiol., 1938, 121: 794.
5. Emge, L. A. Sarcomatous degeneration of transplantable mammary adenofibroma. Arch. Path., 1938, 26: 429.
6. Emge, L. A., and Murphy, K. M. The influence of long-continued injections of estrogen on mammary tissue. Am. J. Obst. & Gynec., 1938, 36: 750.
7. Idem. Effect of rapidly repeated pregnancies on transplantable mammary rat adenofibromas. Proc. Soc. Exper. Biol. & Med., 1938, 37: 620.
8. Emge, L. A., Murphy, K. M., and Schilling, W. Effect of theelin on transplantable mammary rat adenofibromas. Proc. Soc. Exper. Biol. & Med., 1938, 38: 21.
9. Emge, L. A., and Wulff, L. M. R. The influence of pregnancy on experimental tumor growth. West. J. Surg. Obst. & Gynec., 1934, 42: 45.
10. Engle, E. T., and Smith, P. E. Some uterine effects obtained in female monkeys during continued estrin administration, with especial reference to the cervix uteri. Anat. Record., 1935, 61: 471.
11. Fibiger, J. Ueber eine durch Nematoden hervorgerufene papillomatoese und karzinomatoese Geschwulstbildung im Magen der Ratte. Berl. klin. Wchnschr., 1917, No. 7; Ztschr. f. Krebsforsch., 1914, 14: 295.
12. Gardner, W. U., Allen, E., Smith, G. M., and Strong, L. C. Carcinoma of the cervix of mice receiving estrogens. J. Am. M. Ass., 1938, 110: 1182.

13. GRAUER, R. C., and ROBINSON, G. H. Pathogenesis of fibroadenosarcoma of the breast. Arch. Surg., 1935, 31: 677.
14. HEIMAN, J., and KREHBIEL, O. F. The influence of hormones on breast hyperplasia and tumor growth in white rats. Am. J. Cancer, 1936, 27: 450.
15. KAUFMANN, C., and STEINKAMM, E. Ueber die Wirkung unphysiologischer Mengen Keimdruesenhormen auf das Genitale weiblicher castrierter Ratten. Arch. f. Gynaek., 1938, 165: 358.
16. LITTLE, C. C. The present status of our knowledge of heredity and cancer. J. Am. M. Ass., 1936, 106: 2234.
17. LOEB, L. Further investigations on the origin of tumor in mice. VI. Internal secretion as a factor in the origin of tumor. J. Med. Research., 1919, 40: 477.
18. Idem. Estrogenic hormones and carcinogenesis. J. Am. M. Ass., 1935, 104: 1597.
19. MCCULLOUGH, K., and DALLDORF, G. Epithelial metaplasia: An experimental study. Arch. Path., 1937, 24: 486.
20. MCEUEN, C. L. Metaplasia of uterine epithelium produced in rats by prolonged administration of estrin. Am. J. Cancer., 1936, 27: 91.
21. MIGLIAVACCA, A. In der Mucosa des Corpus und der Cervix uteri beim Affen hervorgerufene pathologische Veraenderungen. Arch. f. Gynaek., 1937, 164: 463.
22. MURRAY, W. S. Ovarian secretion and tumor incidence. J. Cancer Research, 1928, 12: 18.
23. OVERHOLSER, M. D., and ALLEN, E. Ovarian hormone and traumatic stimulation of monkey's cervix to a condition resembling early carcinoma. Proc. Soc. Exper. Biol. & Med., 1933, 30: 1322.
24. PERRY, ISABELLA H., and GINZTON, L. The development of tumors in female mice treated with 1:2:5:6 dibenzanthracene and theelin. Am. J. Cancer, 1937, 29: 680.
25. SLYE, MAUDE. Relation of heredity to cancer. J. Cancer Research, 1928, 12: 83.
26. SUNTZEFF, V., BURNS, E. L., MOSKOP, M., and LOEB, L. On the proliferation changes taking place in the epithelium of vagina and cervix of mice with advancing age, etc. Am. J. Cancer, 1938, 32: 256.
27. TAYLOR, JR., H. C. The pathology of the ovarian hormone with special reference to its rôle in tumor development. Am. J. Obst. & Gynec., 1938, 36: 332.
28. ZONDEK, B. Hypophyseal tumors induced by estrogenic hormone. Am. J. Cancer, 1938, 33: 555.

MULTIPLE PLASTIC OPERATIONS IN THE MANAGEMENT OF PROLAPSUS UTERI

EDWARD A. SCHUMANN, M.D., F.A.C.S., Philadelphia, Pennsylvania

PROLAPSE of the uterus is usually defined as a downward herniation of that organ and is said to be complete or incomplete according to whether the entire uterus protrudes from the vulva or only a portion appears. Most definitions go on to state that there is an associated elongation of the broad and uterosacral ligaments, with relaxation of the anterior vaginal wall and cystocele, together with relaxed and generally lacerated perineum.

These definitions do not sufficiently differentiate the various types of complete prolapse with respect to the nature of the associated lesions, a most important consideration from the surgical aspect, when one must decide what type of operation or operations will best meet the specific indications.

TYPES OF PROLAPSUS UTERI

The first type considered is prolapse in multiparous women, with relaxation and dilatation of the vagina but without either cystocele or definite laceration of the perineum. This variety of procidentia is not uncommon and has been especially observed among those women with a tendency to ptosis of the abdominal organs. While it is true that in these subjects the bladder does protrude, it is noteworthy that the greater the vesical distention the higher the bladder withdraws into the vagina. The apparent cystocele disappears from sight either wholly or in part. In this variety palpation of the perineum will disclose a fairly firm floor, the sulci uninjured, and the levators competent although more or less relaxed.

The second type is prolapse in multiparous women with marked laceration of both the anterior vaginal wall and the perineum. The cystocele increases in size as the bladder fills and there is a large thin walled rectocele (sometimes with enterocele) indicating profound injury to the muscles and fascia of the pelvic floor.

The third clinical variety is a compound of the first two types, i.e., prolapse with marked cystocele and a firm perineal floor, or the reverse. This compound type is fairly common and the writer has often been impressed by the apparent integrity of the pelvic floor among women in whom complete procidentia was present with huge cystocele.

The fourth and rarest variety is prolapse of the small uterus of the nulliparous and sometimes virginal woman.

The cause of prolapsus uteri is generally conceded to lie in a stretching and loss of tone of the supports of the organ together with injury to the tissues forming the vaginal canal. With the support being lost, intra-abdominal pressure slowly forces the uterus downward.

The anatomy of the pelvic supporting structures is most complex and so many fasciæ and ligaments have been described that the whole subject has been rendered into a state of confusion. The matter has been condensed and simplified by Frank whose brief and practical summary will be used here. The pelvic organs are held in place by two sets of structures:

1. There is an upper or holding apparatus consisting of those fasciæ and masses of connective tissue occupying the subperitoneal space, i.e., the space between the peritoneum and the levator fascia. This space is entirely filled with connective tissue which may be loose and areolar, or thrown into firm fibromuscular and ligamentous bands. Passing through these masses of connective tissue are found the urethra and vesical neck, the vagina and the rectum, together with blood vessels, nerves and lymphatics. This mass of connective tissue falls into three principal divisions, all originating in the juncture of the cervix uteri with the lateral pelvic wall.

The name, "cardinal ligaments," has been applied to the most important of these divisions but the term is somewhat misleading because no definite ligaments can be demonstrated. The space between the supravaginal cervix and the lateral pelvic wall is filled with a dense mass of connective tissue, the fibers of which form bands of different length and thickness, radiating in a sort of fan shape from the pelvic wall to the cervix and which very firmly connect these structures to each other.

At a lower level similar bands attach the vaginal fornices to the pelvic wall, and higher up

Presented in the Symposium on Obstetrics and Gynecology before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

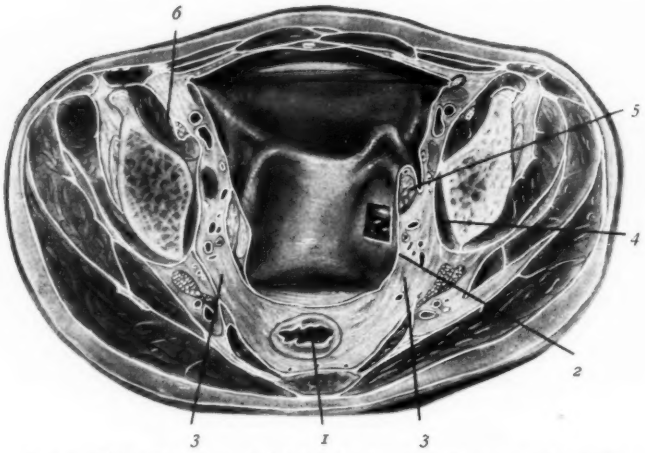


Fig. 1. The section passes just below the juncture of sacrum and coccyx, through the anterior superior spine of the ilium and the great scrotic notch. *1*, Rectum; *2*, peritoneum on lateral margin of cul-de-sac; *3*, connective tissue of the parametrium; *4*, obturator internus; *5*, ovary; *6*, iliopsoas. (Redrawn after Eycleshymer and Schoemaker: *A Cross Section Anatomy.*)

the connective tissue gradually thins and merges into the peritoneal folds of the lower aspect of the broad ligaments. These connective tissue masses, the so called cardinal ligaments, are the essential structures for holding the uterus in place and, so long as their fibers remain uninjured and unstretched, prolapse of the uterus is impossible no matter what other anatomical defect may be present.

Figures 1, 2, and 3 all represent cross sections of the female pelvis, redrawn from *A Cross Section Anatomy*, by Eycleshymer and Schoemaker. They illustrate admirably the extent of the connective tissue into which the cervix uteri and the vault of the vagina are set, as it were, and the tremendous importance of these structures in the maintenance of the uterus in its normal station.

The entire levator muscle may be removed, and the triangular ligament may be divided, but the uterus will still retain its position provided the cardinal ligaments are intact. It is true, however, that when the lower supporting structures have lost their integrity, long continued intra-abdominal pressure exerted upon the fundus uteri will eventually stretch the cardinal ligaments until prolapse results.

The second group of holding structures is the pubocervical ligaments which are massed fibers of connective tissue extending from the lower posterior surface of the symphysis and pubic rami to the cervix, and blending with its wall up to the level of the internal os. Laterally these fibers merge with the anterior aspect of the cardinal ligaments and are attached also to the true fasciæ of the bladder and vagina near the median line. These ligaments are strong supports of the uterus but are secondary in importance to the cardinal ligaments.

The third division comprises the so called sacro-uterine ligaments which run from the posterior aspect of the cervix at its junction with the fundus backward and outward to the sacro-iliac joints. Their effect in maintaining uterine position has been much overemphasized.

All of the above structures, as has been said, are designed to hold the uterus firmly in position, their elasticity permitting lateral or anteroposterior movement or even some transitory descent.

2. The supporting tissues of the uterus and adnexa are those of the pelvic diaphragm, the levator ani and coccygeus muscles with their enveloping fasciæ and the triangular ligament, which fills in the triangle under the pubic arch and closes the space left by the failure of the two levators to unite anteriorly. This pelvic diaphragm forms a secondary support for the uterus; the muscles by their contraction resist the excessive downward pressure from above, and by the maintenance of muscle tone they take at least a portion of the strain of holding the uterus from the cardinal ligament as well as from the associate tissues.

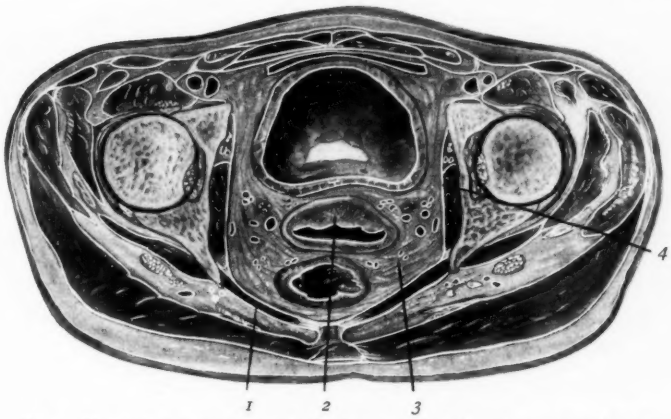


Fig. 2. The section passes through the lower part of the coccyx and the spine of the ischium, through the middle of the acetabulum cutting the head of the femur. *1*, M. coccygeus; *2*, cervix at level of internal os; *3*, connective tissue of the parametrium and cardinal ligaments; *4*, fascia of obturator internus. (Redrawn after Eycleshymer and Schoemaker: *A Cross Section Anatomy.*)

CAUSE OF PROLAPSE

The cause of prolapse lies in a relaxation of the cardinal ligaments, primarily, the descensus being facilitated by incompetence of the pelvic diaphragm resulting from injury or overstretching. That the holding apparatus is primarily responsible is shown by the fact that many women suffer for years from severe laceration of the pelvic floor with large rectoceles but there is no uterine descent whatever.

Conversely, it is noteworthy how many cases of complete prolapse reveal insignificant injury to the levators and the pelvic diaphragm. The term "hernia" has been applied often to uterine prolapse but the mechanism of this lesion does not seem to justify its use, the process being that of a true ptosis rather than a hernia. The writer has been long in accord with the view that simple mechanical factors are not sufficient to explain the occurrence of procidentia uteri, but that there must be some systemic condition present among women presenting this condition in addition to tissue injuries.

Dr. Robert J. Griffin, some years ago, made the interesting observation in Kensington Hospital that advanced dental caries was far more prevalent among women suffering from prolapse than in those patients of comparable age who entered the hospital with other pelvic disorders. Whether this phenomenon is merely a coincidence or a true relationship has yet to be shown, and the staff of this institution is now planning an investigation into the question of the metabolism of prolapse cases in an attempt to throw some light upon the subject.

Defective carbohydrate mechanism as a factor in loss of muscular tone is well known and probably also plays a part in the etiology of prolapsus uteri. This fact has been emphasized by Campbell who presents a suggestive series of blood sugar studies made upon women with birth trauma.

MANAGEMENT OF UTERINE PROLAPSE

The non-operative treatment of prolapse, the use of the pessary in women who are bad surgical risks, the question of the type of operation to be preferred in women of child bearing age, preoperative treatment, and so on are matters of paramount importance; but since this communication is limited to a consideration of certain surgical measures only, the other phases of the subject will not be considered.

Earlier surgical measures for the relief of prolapsus uteri generally included some intra-abdominal procedure as ventrofixation, the fascial interposition of Kocher, or uterine suspension in some form. Gradually the intraperitoneal portion of the operation has been abandoned until now most gynecologists utilize the vaginal approach alone and do not augment the operation by any form of abdominal elevation of the uterus.

The operations for the cure of prolapse in widespread use are: vaginal hysterectomy, the Watkins interposition, the Manchester or Fothergill operation, and the Le Fort procedure.

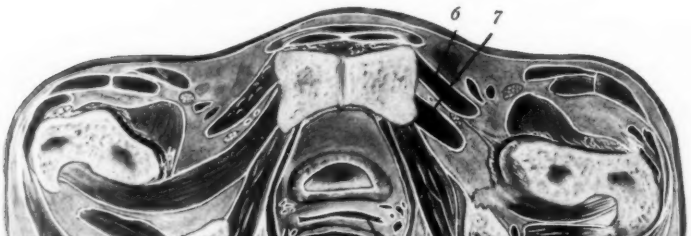


Fig. 3. The section passes through the upper part of the symphysis pubis and the tuberosity of the ischium hence below the externa os. *1*, M. quadratus femoris; *2*, m. obturator internus; *3*, connective tissue forming support of vault of vagina; *4*, rectum; *5*, vagina; *6*, m. pectineus; *7*, m. obturator externus. (Redrawn after Eycleshymer and Schoemaker: *A Cross Section Anatomy.*)

The choice of operation which will best meet the indications in each particular case is a matter of the utmost importance, and it would seem unwise to select one of the foregoing procedures and apply it to a large series of patients without reference to the type of prolapse peculiar to the individual patient. Each patient should be considered individually.

In the clinic of the writer vaginal hysterectomy in general is limited to patients presenting associated uterine lesions as multiple small fibroids, chronic metritis, severe cervicitis, and the like. In the treatment of prolapse *per se* this operation plays a comparatively small part. When indicated, however, vaginal hysterectomy is of great value nor is it the purpose of the discussion to minimize the importance of extirpation of the uterus by this means.

It has long been the opinion of the writer that the supravaginal portion of the cervix forms the best foundation or bearing from which to secure support for the ptosed uterus, and that such support is more easily obtained when the cardinal ligaments are allowed to remain intact rather than severed from their cervical insertion.

This principle may well be utilized, even when hysterectomy is indicated, by performing this operation via the vaginal route but permitting the cervix to remain. In other words it is a vaginal supracervical hysterectomy. The remaining cervical stump is used as a support for the vault of the vagina.

An operation of this type was performed by the late J. M. Baldy many years ago but was never reported by him. Recently supracervical hysterectomy in prolapse has been excellently described by Richardson who has devised a technique by which the upper segment of the cervix is utilized as a support for the vaginal vault. The reader is referred to Richardson's paper for the details of this important addition to the surgical management of a prolapsus uteri.

Of the three remaining plans of treatment, each controls 1 or more phases of procidentia admirably but fails to correct certain other aspects of the lesion. It is the purpose of this paper to point out the great advantages to be gained by utilizing 2 or even more of the specifically described operations under appropriate circumstances.

THE USE OF MULTIPLE OR COMPOSITE OPERATIONS

Watkins interposition plus Manchester procedure. In a case of prolapse of the first type wherein the uterus is in complete procidentia but where neither the anterior nor the posterior vaginal wall has suffered much damage, the descent is produced almost entirely by the relaxation and stretching of the connective tissue supports of the uterus, the cardinal and the supplementary pubovesical and uterine small ligaments. As has been stated, cystocele is a negligible factor in cases of this type. Here the Manchester-Fothergill technique gives admirable results because it

shortens and plicates the paracervical connective tissue and elevates the uterus to its proper plane in the pelvis. Under such circumstances then, an operation of one type is sufficient to meet the indications.

In the second type of prolapse, when there has been widespread injury to the anterior vaginal fasciæ and the levator ani, and when cystocele is a prominent factor, the Manchester operation is not so well suited. Even though the uterus be elevated properly, the thinned-out vesical fascia does not offer support firm enough to retain the herniated bladder, and recurrences of the cystocele in some measure is not uncommon if the Manchester procedure be used alone.

On the other hand the Watkins interposition operation is admirably fitted to buttress the weak fasciæ, the corpus uteri forming a plug which serves to close the hernial opening.

However, control of the cystocele is not sufficient. The holding structures of the uterus, the cardinal ligaments, are not affected by this procedure and hence the too frequent failure of the operation. The prolapse recurs even though the anteflexed uterine body continues to restrain the bladder. Under these circumstances the performance of a multiple or composite operation often solves a difficult problem. If a Watkins interposition maneuver is supplemented by a Manchester operation, all of the relaxed tissues will have been restored and all of the indications met.

In the third type of prolapse described, those cases in which either cystocele or rectocele complicates the procidentia, similar composite operations may be performed to advantage.

Vaginal hysterectomy plus Le Fort operation or partial colpocleisis. In certain instances when vaginal hysterectomy is indicated for prolapse by reason of some uterine pathology, it is found that the vaginal walls are extremely relaxed and all too often inversion of the vaginal vault a few months after operation renders the patient as unhappy as before. This accident occurs even after the most meticulous technique has been employed and even in the hands of the most accomplished gynecologists.

To avoid this unpleasant sequence, it is often advisable to combine vaginal hysterectomy with a partial colpocleisis or Le Fort operation. Such a plan is especially valuable in old women with marked loss of muscle tone and greatly stretched out vaginal canals. The apposition of the vaginal walls adds but little to the time of the operation and should not contribute to morbidity or mortality.

Watkins interposition plus Le Fort operation. Another troublesome form of prolapse is that in which a huge cystocele is attended by greatly relaxed vaginal walls, but the descensus of the uterus is not excessive. This lesion is fairly common among old women and is difficult to correct by any single operation. Here a Watkins interposition will maintain the bladder in position but the relaxed vaginal vault is best held by a Le Fort operation.

Indications for the employment of composite operations will occur to everyone engaged in gynecological surgery and, indeed, multiple operations are doubtless commonly utilized by operators in this field. It must be clearly understood, however, that many cases of prolapse are perfectly manageable by the performance of one of the standard procedures with adequate repair of the pelvic floor and with these cases the present discussion has no concern. However, in any series of operations for the relief of prolapse there are to be found a considerable number of failures, many of which would have been prevented had a composite operation been performed.

It has been thought unnecessary to include illustrations of the various operations under discussion since the technique of these procedures is common knowledge among gynecologists.

CONCLUSIONS

1. Prolapse of the uterus is due primarily to a relaxation and stretching of the parametrial connective tissue, the holding apparatus of the uterus.

2. Loss of tone and injury to the pelvic floor is a secondary factor in the etiology of prolapse. It is operative only because of the unbalance of the forces involved, namely the continuous downward thrust of intra-abdominal pressure which normally should be opposed by an elastic and strong pelvic diaphragm.

3. Prolapse cannot occur when the cardinal ligaments and other portions of the holding apparatus are tense and uninjured, regardless of the state of the pelvic floor. It can occur, however, when these ligaments have lost their tone even though the levator ani and associated muscles and fasciæ are comparatively uninjured.

4. From the viewpoint of surgical cure, prolapse must be divided into several clinical varieties, dependent upon the associated lesions.

5. The upper segment of the cervix uteri and its attached cardinal ligaments offer the best support to the uterus and vaginal vault, and hence vaginal hysterectomy should play but a small part in the surgery of prolapse *per se*. On the other hand, vaginal hysterectomy with the reten-

tion of a collar or disk of cervix (Richardson) is a well designed procedure of great value.

6. The utilization of various operative techniques in the performance of multiple or composite operations, when required to control prolapse of different types, is the method of choice in the approach to this problem.

REFERENCES

1. Campbell, A. D. Am. J. Obst. & Gynec., 1937, 33: 209.
2. Frank, Robert T. Surg., Gynec. & Obst., 1917, 24: 42.
3. Richardson, E. H. Am. J. Obst. & Gynec., 1937, 34: 814.

WERTHEIM OPERATION FOR CANCER OF THE UTERUS

PROFESSOR PAUL WERNER, Vienna, Austria

THE Wertheim operation for carcinoma of the uterus is not a new subject. Over 40 years ago my teacher, Wertheim, originated and developed the technique for this operation, and this procedure has been improved further by countless gynecologists the world over. Nevertheless, the fight against cancer of the cervix, which claims thousands of women yearly, continues to stimulate most of us to still greater efforts.

It is my purpose to limit my remarks to a discussion of measures designed to reduce the high mortality rate resulting from the high incidence of postoperative peritonitis. Without doubt the Wertheim technique permits greater exposure, and, therefore, a more extensive resection, and a more satisfactory examination and removal of involved lymph glands than does any other surgical operation for cancer of the cervix. The Wertheim, therefore, fulfills the primary requirements for successful surgical procedures against cancer anywhere in the body. Despite this, we are obliged to admit that this operation has been discarded in the past few years by many surgeons in favor of other operative or non-operative measures due to fear of the attending high mortality, which varies from 10 to 20 per cent with different surgeons, yes, even 30 per cent, according to reports in the literature of those patients in whom the Streptococcus hemolyticus could be recovered from the ulcer. The postoperative deaths are due largely to peritonitis. This is easy to understand, for the carcinoma is associated invariably with various pathogenic organisms, so that the operation of necessity is performed in a septic field.

From the Department of Gynecology of the Rudolfspital of Vienna.

Presented in the Symposium on Obstetrics and Gynecology before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

The latest suggestion to reduce the incidence of postoperative infection and peritonitis was made by Louros, of Athens, and presented by him in Amsterdam on May 4, 1938, at the last International Congress for Obstetrics and Gynecology. He modifies an old idea of Zweifel who, in order to reduce the possibility of infection resulting from the opening of the vagina from above, recommended burying the uterus deep in the pelvis after its separation from the bladder, rectum, and walls of the pelvis, and reperitonealizing over it with bladder and rectum. The abdomen is then closed, and the patient placed in the lithotomy position. After circumcising the vagina, the uterus is withdrawn and the parametrial wounds are packed. Louros adopted this method with a modification. He employs the mesosigmoid, rectum, and mesorectum after closure of the parametrial slit instead of the bladder and rectal peritoneum. After the uterus is removed *per vaginam* he approximates and fixes the surfaces of the plica vesico-uterine and recto-uterine to the vaginal walls, which are then closed. Louros maintains that his modification has these advantages: closure of the peritoneum is facilitated especially if inflammatory areas are present; injury to the bladder and rectum during the preparation of the peritoneal flaps is avoided; and, finally, there is no communication between the parametrial wounds and the vagina.

Our method to avoid postoperative peritonitis is altogether different and is based upon the 3 following points:

The anesthetic. The entire field of operation must be considered potentially infected. With inadequate anesthesia the small bowel is forced down into the field of operation and may thereby be contaminated. For that matter even the repeated forced reposition of such a bowel will

injure the serosa rendering it less resistant to infection. Moreover, the separation of the rectum from the posterior vaginal wall is especially painful, a manipulation that will prompt the patient to move and to press down even under deep inhalation anesthesia. All this can be avoided only with a truly effective spinal anesthesia. Therefore, when doing a Wertheim operation, we employ spinal anesthesia exclusively, using 8 to 10 cubic centimeters of 0.1 per cent percaine solution, and administer veronal and morphine as pre-operative sedation. Furthermore, this anesthesia effects complete relaxation facilitating gentle and quick manipulation.

Preparation. Not only the superficial but also the deeper structures of the carcinomatous growth contain bacteria. Each manipulation of the tumor tends not only to force these bacteria still deeper into the uterine tissue but also to infect the entire surrounding connective tissue. For this reason no woman with cervical carcinoma should have a pelvic examination done for at least 2 days prior to the operation. Curettage, cauterization, or tamponade must also be avoided previous to operation. Wertheim, himself, used to curette and cauterize just before operating, believing that he could thereby remove infected and necrotic tissue. Such preparation is not only superfluous but, on occasion, is even dangerous.

Precautions. To prevent the introduction of infected tissue fragments into the peritoneal cavity from the opened vagina Wertheim used right-angled clamps, the so called "knee-clamps," with which he clamped the vagina below the isolated tumor, dividing the vagina below the clamps. The application of these knee-clamps can be difficult occasionally, especially when the tumor extends far down into the vagina; furthermore, due to inaccessibility it is sometimes difficult to effect division of the vagina below the clamps. Therefore, we discontinued using them and divide the vagina in the following manner: only after the rectum and bladder have been completely separated and the parametrium resected, so that the carcinomatous growth is supported solely by the vagina, is the vagina painstakingly cleaned with dry gauze from below. Two gauze sponges are introduced into the vagina as high as possible and against the carcinoma, following which, the vagina below this is again cleaned with dry gauze. The surgeon after changing gloves returns to the open abdomen. Grasping the specimen with the left index finger and thumb, and compressing the vagina below the gauze tampons, he opens the anterior vaginal wall with scissors at a level below his fingers. Through this opening then is introduced another gauze tampon into the distal part of the vagina. Following this, division of the vagina is completed. When this technique is practiced it is always possible to prevent the introduction of cancerous fragments into the abdominal cavity.

The results achieved in our carcinomatous patients by the observation of these simple measures can be shown by a brief report of operative results. This routine was employed for the past 9 years, during which time 294 women with carcinoma of the cervix were admitted to our dispensary. Of these, 63 were considered inoperable at once from either physical examination alone or after exploratory laparotomy, and they were referred for irradiation therapy. So, 78.58 per cent of our patients fall into the operable class. In 1932, Halban stated that various surgeons report an average operability of 50 to 60 per cent. It, therefore, appears that our operability rate is rather high due to the fact that we also operate upon very advanced cases.

Two hundred and thirty-one women were operated upon; of these, 152 were operated upon according to the Wertheim technique, 65 according to Schauta-Schuchardt, 2 according to Halban, and 12 had a simple vaginal hysterectomy. The latter 12 were young women, with very early cancer, the diagnosis of which in most of them was established first through biopsy. The 67 patients who were operated upon according to Schauta-Schuchardt, or Halban, were also early cases, in whom the carcinoma was either restricted to the cervix or in whom the growth had extended but very little.

So these patients upon whom a Wertheim operation was performed included not only the advanced cases but also borderline cases. According to Winter's classification most of our patients would be included in Class III and even Class IV. This is proved by some notes taken from the operative findings. In 52 patients enlarged lymph-glands were found and extirpated, during which the obturator nerve in 1, the iliac vein in 6, and the iliac artery in 2 had to be resected because the carcinomatous glands so completely involved these structures that they could not otherwise be removed. In 40 patients it was exceedingly difficult to separate the bladder; it was actually necessary a few times to resect a small portion of it and once even the entire fundus of the bladder. In 33 patients considerable difficulty was encountered in separating the ureters (including 3 resections of the ureter), and in 6 difficulty in separating the rectum. In 11, extensive pelvic inflammatory changes were found, and in 6 patients the tumor

ruptured during the operation despite every precaution taken to prevent this. In 40 patients the parametrium was infiltrated laterally to such an extent that its complete removal exposed even the levator ani.

There were 12 deaths in these advanced cases, a mortality rate of 7.96 per cent. There were 5 deaths due to pulmonary embolism, 2 to pneumonia, 1 postoperative hemorrhage, 1 to the anesthetic, 1 to cerebral edema, 1 to multiple sclerosis, and 1 to retroperitoneal abscess. The deaths due to pulmonary embolism occurred 1, 4, 5, 6, and 14 days, respectively, after operation despite the use of every precaution to prevent it. All were advanced cases in which large, raw surfaces remained due to the very extensive resection. The anesthetic death occurred in a woman whose inadequate spinal anesthesia had to be supported with 100 cubic centimeters of open ether. Here, the autopsy revealed a marked myocarditis. Death, in the patient with retroperitoneal abscess occurred 3½ months after operation; it is more than likely that death in this case was due to poor postoperative care rather than to any fault of operative technique. When one considers that all these deaths occurred only in patients with advanced carcinoma of the cervix, the 8 per cent mortality rate is really rather low. At any rate we were able to perform 152 successive, difficult Wertheim operations without 1 patient developing peritonitis. These results certainly appear to justify the points of technique mentioned.

I regret that it is impossible to compare our findings with those obtained by Louros with his technique, and presented by him to the International Congress in Amsterdam, because the reports of the Congress failed to include his results. However, we believe that our technique saves time and is simpler, because it is unnecessary to change the position of the patient during the operation, thus permitting it to proceed without any interruption. The results obtained by this technique justify its further trial by our colleagues.

CERTAIN ASPECTS OF SO CALLED STERILITY IN THE FEMALE

A. D. CAMPBELL, M.D., C.M., F.A.C.S., M.C.O.G., F.R.C.S.(c), Montreal, Quebec

THE problem of sterility is one which concerns not only ourselves as gynecologists, but the general practitioner, the urologist, and the internist. The biochemist and the physiologist, while not directly concerned with the human problem, are able nevertheless to give invaluable aid to the clinician in the study of individual cases. Since distant foci of infection may influence the reproductive tract, even such an apparently remote specialty as otolarynology may be able to render distinct help.

I should like in this brief communication to deal only with those cases in which the female is entirely at fault, and in whom, on examination, no lesion is apparent or palpable in the pelvic organs. Aldridge reported that 66 per cent of cases of sterility have partial or complete obstruction of the fallopian tubes and that in 44 per cent of these the pelvic examination is negative. It is probably common experience that about one-third of all cases of so called female sterility display no detectable lesion in the pelvis.

There are in this group of cases 3 main causes for the sterility which they manifest. In the first place, there may be no ovulation; in the second place, the liberated ova may be unable to find their way into and through the fallopian tubes, and in the third place, the condition of the reproductive tract in general, and of the endometrium in particular, may be inimical to fertilization, or perhaps more often to the maintenance and implantation of the fertilized ovum and the embryo. Of these 3 main divisions, the second appears to be, superficially at least, an anatomical or mechanical problem; whereas the first and third in the many instances are primarily problems in applied endocrinology, since the anterior pituitary hormones exercise chief control over the process of ovulation, and the hormones of the ovary itself regulate the development and activity of the tissues of the reproductive tract.

Occlusion of the fallopian tubes is often due to some mild inflammatory process. It should be borne in mind that peritoneal reaction as a result, for example, of regurgitation of blood through the tubes in certain cases of abortion, or of irritation of a chemical nature caused by high pressure douches, or even ordinary soap-sud douches, such as are used so extensively in England, may lead to the production of occluding lesions which are not palpable. Tuberculosis must always be borne in mind, not only as a possible cause of sterility, but because of the appalling risks with which it invests procedures otherwise comparatively safe. I am anxious to insist upon this point, since I have seen 3 cases in which, though the history and the physical examination gave no warning, insufflation of the tubes precipitated active pelvic tuberculosis. Recently the lesson was emphasized by a fourth case in which tuberculosis of the endometrium was encountered on examining microscopic specimens of endometrium. Such a finding being pathognomonic of tuberculous salpingitis, a panhysterosalpingectomy was decided upon. When the abdomen was opened the tubes appeared to be perfectly normal, yet on microscopic examination the tubal mucosa was found to be studded with tubercles. In the light of these experiences the use of insufflation, which many employ lightheartedly either for diagnostic or for therapeutic purposes, should be most carefully considered. The injection of iodized oil, furthermore, is not entirely free from danger (43).

It is to be considered, too, that even when sterility is actually due to tubal occlusion, or in more general terms to failure of the ova to attain the uterus, it is not necessarily futile to attack the problem by endocrinological methods.

Kaufman and others have shown that the administration of estrin not only causes the tubal musculature to develop, but actually leads to an enlargement of the lumen and development of the cilia. Seckinger and Snyder, as early as 1926, found that the activity of the muscular wall of the tube paralleled, chronologically, the changes in the endometrium and tubal mucosa; at midinterval and for some days thereafter, the contractions were rapid and of varying amplitude; while in the premenstrual and menstrual phases, and throughout pregnancy, they were slower, smaller and more uniform.

In a recent experimental study Geist et al., using the method of Rubin as a means of recording the

Presented in the Symposium on Obstetrics and Gynecology before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

tubal contractions, have shown quite conclusively that after the menopause, with the gradual cessation of production of estrogenic hormone, there is a marked impairment of activity of musculature of the fallopian tubes and gradual disappearance of the regular rhythmic tubal peristalsis. Coincident with the impairment in tubal contractility the vaginal smears exhibited signs of various degrees of estrin deficiency. The most marked deficiency was seen in those patients showing least tubal activity. Administration of estrin resulted in the development of rhythmic contraction waves of high amplitude, similar to those observed in normal females. Simultaneously with the re-appearance of tubal contraction, the vaginal smears showed the full effects of estrin upon the mucosa. This excellent experimental study seems to justify our impression (4, 5) that impairment of tubal contractility, due to estrin deficiency, may play a rôle in some form of sterility and tubal pregnancy.

The transporting mechanism in the genital tract deserves further consideration. G. H. Parker has shown that the ciliated epithelial cells in the tubal mucosa waft the ova downward while the contractions in the tubes themselves appear to force the sperm upward. It is not inconceivable that an individual exaggeration of the upward-directed force may, first, cause relative sterility by opposing the descent of the ova; second, by permitting premature fertilization or similarly by interference with the descent of the fertilized egg, tend to encourage ectopic gestations, whose tendency to recur requires no emphasis; and third, by favoring upward migration of detached fragments of viable endometrium, play an important rôle in the causation of endometriosis. From time to time, one encounters associations among these 3 phenomena which may have in common some endocrinological etiological factor.

It is also clear that deviation from normal in the endometrium may seriously affect the fertilized ovum before, as well as after, implantation. Since insemination will, only rarely, take place at the very hour when the ovum awaits fertilization, it is most important that the female tract should be hospitable to the sperms. The presence of infection not only in the vagina but in the cervical canal is inimical to the life of the sperm. Such infection may not give rise to purulent discharge, but pathogenic and pyogenic organisms in the vagina have been said to be responsible for some 50 per cent of cases of sterility. Endometritis following the use of the stem pessary is an infection contributing to unsuccessful insemination.

Marshall and Jolly first demonstrated the effect of ovarian secretion on the vaginal mucosa.

The observations of Seguy and Vinneux suggest that the variations which occur in the hydrogen-ion concentration and also in the physical character of the cervical secretions throughout the cycle may be of considerable importance in relation to the ascent of the sperm. They observed that at about mid cycle there was an increase in the hydrogen-ion concentration, and that, coincident with this change, the secretion in the cervical canal became less tenacious and more translucent. It is possible that this comparatively simple procedure of testing the character and hydrogen-ion concentration of the cervical secretion at different periods of the cycle may be found ultimately to be of value.

One may commence the endocrine investigation of cases of sterility by obtaining a detailed menstrual history. The apparent menstruation of early adolescence is of relatively little importance here, since we believe that in many instances these demonstrations are only pseudomenstrual. In the immature rodent, an induced first cycle is usually anovulatory.

It is generally held that the corpus luteum is essential for normal menstrual cycles, but I believe that this dogma must be modified, as pointed out in a previous communication by Campbell and Collip (6). Moreover, Corner and Hartman have shown that the corpora lutea are not necessarily present in ovaries showing cyclic activity as manifested by menstruation.

Unfortunately, pseudomenstruation is clinically indistinguishable from true menstruation. After the patient has reached her *menstrual stride*, an accurate history should be analyzed as to the length of the interval, the amplitude and duration of flow, and the presence or absence of pain.

Sir Henry Whitehouse has stressed the difference between premenstrual pain (dysmenorrhea) and pain (menorrhalgia) occurring during the actual flow. The latter, in his experience, suggests a foreign body such as polyp, unshed endometrium or leiomyoma, in the uterus; while he finds premenstrual pain to be associated with a particularly highly developed progestational type of endometrium, the cells in the strata compacta simulating decidual cells, probably produced by too vigorous or too prolonged production of the hormone of the corpus luteum. Excessive duration of flow (over 5 days), or an increasing amount of hemorrhage, must always first suggest the presence of some occult lesion in the uterus or pelvic organs.

The length of the interval is probably the most significant single factor to be gleaned from the personal history; it is unfortunate that many women are convinced that their periods recur regularly

every 28 days, when in fact accurate recording reveals considerable instability. In my experience it is exceptional for a woman whose cycles are shorter than 27 days to become pregnant; it may be that fertilization occurs, but the embryo is aborted on the twenty-seventh day, not having become firmly established before luteal function regressed. The length of the cycle depends upon the complex interactions between the ovary and the anterior pituitary; for, while the anterior lobe hormones determine follicular maturation and the formation of corpora lutea, the hypophysis is itself influenced by the hormones produced by the developing follicle and also by the hormone of the corpus luteum (11). If any link in this chain of stimulation and inhibition is weak, it may well happen that the corpus luteum can not of its own pituitary-controlled vitality sustain the endometrium until the twenty-eighth day of the cycle; until the time, that is, when the corpus luteum may be re-activated and vitalized by *prolan* produced by the developing and implanted embryo. In such cases, the outlook becomes more hopeful if it is found possible to increase the length of the interval; even if only an occasional cycle reaches the desired length, there is always hope that a pregnancy may be successfully established on 1 of these favorable occasions.

More detailed endocrine investigation is a matter of greater practical difficulty; biological assays of estrin and other sex hormones in the urine, or more rarely in the blood, has been practiced with success by Frank et al., Fluhmann (22, 23, 24), and many others; but it demands the services of a competent biochemist, and is vastly expensive both in regard to time and animal material if efficiently done.

To make a really complete survey of the endocrine status of each case, it would be necessary to assay each and every one of the plurality of pituitary hormones; at present an inconceivable task. Furthermore, it emerges from the work of Collip (12, 13, 14, 15) and his associates that to each of these hormones there may be an antagonistic anti-hormone which would also have to be measured quantitatively; there is indeed evidence of the presence of such substances in the blood of many patients with amenorrhea. Moreover, since both the ovarian and the pituitary hormones are produced in fluctuating quantity, biological analysis of single or occasional samples of blood or urine can never fully enlighten us as to the endocrine levels throughout the cycle.

Study of the structure of the endometrium is also open to this objection, that it furnishes only an instantaneous cross-section of a continuously changing function; nevertheless, valuable information may be obtained in this way. Bland found that in some 23 per cent of sterility cases the premenstrual endometrium strongly suggested anovulatory cycles; Mazer encountered this still more frequently. One may avoid the risk of damaging a healthy endometrium, or even of interfering with an early pregnancy, by obtaining samples within 10 hours of the onset of bleeding. Properly interpreted, the slides reveal fairly accurately the course of events in ovarian activity in the preceding period, though of course only very roughly quantitative evaluations can be made on the basis of microscopic examination.

The time of ovulation can be assumed in a few instances, where it is marked by pain or by slight hemorrhage; but in the majority of cases the determination presents a formidable problem. Sudden increases in excretion of prolan, and perhaps of estrin, may serve as markers; but the cost and difficulty, as previously mentioned, of detecting them restrict their use. The electrical detection of ovulation of Burr and Allen, requires much elaboration before it can be of practical clinical use. Special attention should be drawn to the most helpful and extremely important work of Venning and Browne (44, 45). They have established a relatively simple chemical procedure for measuring the quantity of pregnandiol excreted in the urine; since pregnandiol is apparently the inactive excretion form of progesterone, the hormone of the corpus luteum, this makes it possible to determine, without too much difficulty, the time when the corpus luteum begins to function as an endocrine organ, i.e., just after ovulation, and to form some estimate of its activity and vigor throughout its active life. Thus in a patient in whom pregnandiol constantly appears at some time other than the fourteenth day of the cycle, one may recommend coitus at or about the time thus indicated. Again, a decreased pregnandiol output in early pregnancy may be regarded as a warning of a threatening abortion, which can possibly be averted by administration of appropriate amounts of progesterone (45). As shown in the recent work of Deanesly and Parkes, there is perhaps the possibility that the implantation of specially prepared discs of crystalline progesterone may afford a practical method of the clinical use of the hormone. However, the appearance of pregnandiol is no certain indication that ovulation as opposed to corpus luteum formation has actually taken place, and of course is no suggestion at all that the ovum is able to pass into the muellerian tract.

Among other aids to endocrinological investigation which have been found helpful, special refer-

ence should be made to the work of Mortimer (34, 35, 36) in using the cranial skiagram as an indicator of anterior pituitary function, past and present. While the shape and size of the sella turcica have been widely used as occasional signs of pituitary abnormality, the outline of any ductless gland is of little guide to physiological activity. Mortimer has called attention more especially to the structure of the calvaria and the degree of development of the paranasal sinuses. Since these are largely controlled by the pituitary growth hormone, and since they change in their form and interrelations during the period of growth, they throw light on the previous activity of the pituitary. For example, the prognosis is not bright in cases of menstrual disorder or apparent sterility, if there is early cranial sclerosis with poor development of the accessory sinuses.

It is always desirable to remember that the endocrine system functions, as an integrated whole, and that disturbances apparently remote from the reproductive tract may have a considerable bearing on the question of sterility. The net should, therefore, be flung widely in search of possible causes of this condition. The thyroid gland, for example, has a profound influence on reproduction, and a basal metabolic rate should be obtained in all cases; although one sometimes doubts whether an apparently normal basal rate can be taken as reliable assurance that the thyroid function is perfectly normal.

Abnormalities of carbohydrate metabolism may also serve as indicators of endocrine disorder; it is noteworthy that menstrual cycles are suspended or disturbed in some 90 per cent of diabetic women of childbearing age, and reappear when the diabetes is properly controlled (39). Still more important is the fact that sterility is not infrequently associated with disturbances of sugar-tolerance which may not necessarily be frankly diabetic in type, and that pregnancy may follow the administration of insulin; and it should be emphasized that glycosuria may be completely absent and fasting blood sugar levels substantially normal in many individuals whose response to the ingestion of sugar in a tolerance test is altogether faulty and inadequate (38). Some 20 per cent of cases with definitely disturbed carbohydrate metabolism do not show glycosuria. It may be noted here that in these cases, as well as in hyperthyroidism, protein catabolism may be increased and thus require an unusually high intake of protein of a high biological or protein-sparing value (39).

Nutritional factors, indeed, often require some consideration. The normal reproductive rhythm is one of the first bodily functions to become disordered when the supplies of good quality protein, or of any of the essential minerals or vitamins is inadequate; as the experience of Central European countries during 1916–1919 sufficiently shows. It has frequently been urged, for example, that there is a correlation between sterility and secondary anemia. Dr. Rolland Kennedy, however, in a recent review (unpublished) of mothers attending the child welfare clinic in Montreal, found that 43 per cent of a series of 1,500 women of childbearing age showed a relative anemia without any disturbance in their menstrual cycles or interference with pregnancy. Since loss of iron-rich blood at menstruation is an important factor in this type of anemia, it is not altogether surprising that there is no correlation apparent between amenorrhea and anemia in a large series of cases.

The endocrine preparations available for therapeutic measures are numerous, but fall into 2 main types as far as their direct influence upon the reproductive tract is concerned. There are first, the ovary-stimulating, or at least ovary-affecting, substances obtained either from the pituitary gland itself, or from the serum of pregnant mares, or from human placenta or pregnancy urine; there are second, the hormones of the ovary itself and their various natural and artificial derivatives.

In the first group we have made use both of the gonadotrophic or *maturity* fraction of anterior pituitary extract, and of the *anterior-pituitary-like* (19) (APL) fraction from pregnancy urine. Collip et al. (16), showed that while both these substances produce luteinization in the ovaries of intact immature rats or mice, they are, nevertheless, fundamentally different; the urinary products are comparatively inert in hypophysectomized animals, and apparently require at least the passive co-operation of the animal's own pituitary gland to unfold their usual effects (17): even so, they have relatively little power to produce genuine ovulation (18). We (7) have found that *anterior-pituitary-like* is capable of correcting certain menstrual disorders. It is of value in the treatment of cases with moderate intermittent intermenstrual hemorrhage, and tends to re-establish normal cycles when there is persistent uterine bleeding due to endometrial hyperplasia or metropathia hemorrhagica (9). Since many patients have become pregnant during or after such treatment, it appears that though *anterior-pituitary-like* may be incapable of producing ovulation on its own account, it has no adverse effect. *Anterior-pituitary-like* should be reserved for cases with obvious disturbance of the endometrium, while the pituitary gonadotrophic extract is indicated when sterility persists in the presence of more or less

TABLE I.—ANALYSIS OF CASES CONSERVATIVELY TREATED WITH EMMENIN

	Cases
Number of patients treated	34
Average age of patients, in years	33
Age of 2 patients at first pregnancy	42
Years of sterility	2.5
Average menstrual periods after treatment	1.5
Number of failures	7
Number of pregnancies	27
Pregnancies terminating in abortion	5
Pregnancies past seventh month of gestation	30
Stillbirths	3
Hydrocephalic, 1; abruptio placentæ, 1; death *in utero*, cause unknown, 1.	
Live births	27
Males	19
Females	8
Maximum weight in pounds	11½
Minimum weight in pounds	6½
Average weight in pounds exclusive of twins	8.4
Weight of twins in pounds: Two pairs — Females 5¼ and 5½; Males 6¼ and 6½	
Average weight in pounds of all live births	8.02
Method of delivery — Spontaneous	7
Low forceps	8
Mid forceps	5
Craniotomy (monster)	1
Cesarean section — Large babies 5; Abruptio placentæ 1; Dead monster (dwarf) 1	7

normal menstrual cycles, since it is more likely to stimulate true ovulation.

The ovarian hormones, now available in manifold forms, some of them of enhanced potency in practice, have also their part to play. In 1930, Collip (8) obtained from human placentas a water-soluble, ether-insoluble, orally-active factor to which the name "emmenin" was given; it is probable that at least the chief active principle in this fraction is similar or identical to the glycuronide of estriol later isolated from urine by Marrian. Emmenin differs from estrone (theelin) in being highly active orally in immature intact rodents (8), but relatively inert in adult castrates. It is with this preparation that I have the most personal experience. The emmenin complex has been found to be of value in the correction of oligomenorrhea (7), even when the menstrual flow, having gradually diminished over a long time, has for some months altogether ceased. On the other hand, suddenly appearing breakage of a previously normal menstrual rhythm is less amenable. In our experience, cycles of normal length are not disturbed by emmenin administration; but in a certain number of cases, short cycles have been lengthened in this way by 1 to 3 days, which probably indicates that emmenin can have a regulating influence upon the pituitary. The normalizing of a somewhat short cycle, as already suggested, is often an invaluable step toward overcoming an apparently causeless sterility. Several patients, receiving emmenin treatment for menstrual disorders, oligomenorrhea or dysmenorrhea, became pregnant; still more successful has been the treatment of patients with sterility but with normal cycles. Since in my experience no patient on a cycle persistently shorter than 27 days became pregnant, only those attaining cycles of normal length are analyzed (Table I).

SOME POINTS OF INTEREST IN CONNECTION WITH CASES STUDIED

CASE 1. The patient who had been given emmenin became pregnant and continued the treatment for 3 months. She delivered at term by means of cesarean section. One year later the patient again became pregnant but without treatment with emmenin and she aborted after the third month. The following year she received medication for 3 months and at the present writing has been pregnant for 7 months.

CASE 6. This patient aborted in second month probably because of early discontinuance of medication. Later when treatment was continued past the third month she delivered at term. This same occurrence holds true of 2 other occasions.

CASE 12. This patient, a hypophyseal dwarf, began menstruation at the age of 17. It was acyclic, occurring only 2 or 3 times yearly. Emmenin was administered and she became pregnant. A premature male, dead, was delivered by cesarean section in another city.

CASE 14. The patient, suffering with oligomenorrhea, had periods of amenorrhea up to a year throughout menstrual life.

CASE 19. This patient, a chronic nephritic, as later events revealed, became pregnant on treatment but in the last month of gestation abruptio placentæ occurred. She was then sterile for 3 years but became pregnant when treated with emmenin. This terminated in ectopic gestation 6 weeks later.

CASE 20. The past history of this patient disclosed that the first pregnancy terminated as pre-eclamptic toxemia with stillbirth. Two years later she had an ectopic gestation and was then sterile for 2 years. Upon treatment with emmenin she became pregnant and delivered at term. There was no toxemia.

CASE 23. This patient, unipara, was 42 years of age. She vomited throughout pregnancy during which she developed edema, and in the last trimester high blood pressure.

CASE 26. The patient developed moderate edema during the last month of gestation without increased blood pressure. The weight of the child was slightly over 11¼ pounds.

Seven patients with no apparent lesion in the pelvis did not become pregnant; later events proved the following:

CASE 23. The patient had pyonephrosis and also pea-like submucosal fibroids.

CASE 34. In this patient tuberculosis was present throughout the entire muellerian tract (referred to in text).

Of the 5 cases remaining regarded as failures, no explanation for their sterility can be put forward.

While this series (which extends over a period of 9 years) is small, it would seem that the weights of the offspring of patients becoming pregnant on emmenin are unusually large, though from calculated dates there was no evidence of postmaturity. Probably the same pertains when pregnancy follows other similar forms of hormone therapy.

Experience would lead one to suggest that sterility frequently results from deranged function of the muellerian tract as a whole or its transporting mechanism, in particular, which in many instances can probably be corrected by emmenin therapy (27, 40). It is well to observe here that when women who have previously appeared sterile become pregnant spontaneously, they show a considerable tendency to abort; and this is true also of women who become pregnant during treatment with emmenin. We have, however, encountered this difficulty only twice since we instituted the practice of continuing the emmenin treatment through the first 3 months of pregnancy.

Maturity fractions of the anterior pituitary gland are reserved for patients who after a 3 months' trial of emmenin do not become pregnant and those who after biological investigations appear to be anovulatory.

It is particularly worthy of note that patients who become pregnant while taking emmenin or commence treatment on missing 1 menstrual epoch very rarely have vomiting of early pregnancy or display symptoms of so called toxemia in the last trimester.

REFERENCES

1. Aldridge. Quoted by Schmitz, Henry. Am. J. Obst. & Gynec., 1932, 23:47.
2. Bland, P. B. Quoted by Mazer, C., Israel, L., and Kasher, L. Surg., Gynec. & Obst., 1937, 65:30.
3. Burr, H. S., Hill, R. T., and Allen, Edgar. Proc. Soc. Exper. Biol. & Med., 1935, 33:109.
4. Campbell, A. D. Lancet, 1932, 2: 561.
5. Idem. Ann. Int. Med., 1933, 7:330.
6. Campbell, A. D., and Collip, J. B. Brit. M. J., 1930, 2:1081.
7. Idem. Canadian M. Ass. J., 1930, 23:633.
8. Ibid. 22:215, 219.
9. Ibid. 1931, 25:9.
10. Collip, J. B. Canadian M. Ass. J., 1930, 22:212.
11. Idem. Tr. Roy. Soc. Can., Sect. V, 1932. 1:137.
12. Idem. Ann. Int. Med. 1934, 8:10.
13. Idem. J. Mount Sinai Hosp., 1934, 1:28.
14. Idem. Ann. Int. Med., 1935, 9:150.
15. Idem. Proc. Ass. Res Nerv. & Mental Dis., 1936, 17:268.
16. Collip, J. B., Browne, J. S. L , and Thomson, D. L. J. Biol. Chem., 1932, 97:xvii
17. Collip, J. B., Selye, H., Thomson, D. L., and Williamson, J. E. Proc. Soc. Exper. Biol. & Med., 1933, 30:590.
18. Ibid. 30:665.
19. Collip, J. B., Thomson, D. L., McPhail, M. K., and Williamson, J. E. Canadian M Ass. J., 1931, 24:201.
20. Corner, G. W. J. Am. M. Ass., 1927, 89:1838.
21. Deanesly, R., and Parkes, A. S. Lancet, 1938, 2: 606.
22. Fluhman, C. Proc. Soc. Exper. Biol. & Med 1933, 31:54.
23. Idem. Endocrinology, 1934, 18:705.
24. Idem. Am. J. Obst. & Gynec., 1936, 32:612.
25. Frank, R., Goldberger, M. A., and Salmon, U. J. Proc. Soc. Exper. Biol. & Med., 1936, 33:615.
26. Geist, S. H., Salmon, U. J., and Mintz, M. Am. J. Obst. & Gynec., 1938, 36:67.
27. Goldberg, M. B., and Lisser, H. Endocrinology, 1935, 19:649.
28. Hartman, C. G. Am. J. Obst. & Gynec., 1930, 19:511.
29. Kaufman, C. J. Obst. & Gynæc., Brit. Emp., 1935, 42:409.
30. Kennedy, Roland W. Personal communication.
31. Marrian, G. F. Bio-Chem. J., 1930, 24:435.
32. Marshall, F. H. A., and Jolly, W. A. Tr. Roy. Soc. B., 1906, 198:123.
33. Mazer, C., and Ziserman, A. J. Am. J. Surg., 1932, 18:332.
34. Mortimer, H. Proc. Ass. Res. Nerv. & Ment. Dis., 1936, 17:222.
35. Idem. Radiol., 1937, 28:5.
36. Mortimer, H., Levene, G., and Rowe, A. W. Radiol., 1937, 29:135 and 279.
37. Parker, G. H. Am. J. Obst. & Gynec., 1932, 23:619.
38. Rabinowitch, I. M. J. Clin. Invest., 1926, 2:585.
39. Idem. J. Med. Soc. N. Jersey, 1936, Sept.
40. Schneider, P. F. Am. J. Obst. & Gynec., 1936, 31:782.
41. Seckinger, D. L., and Snyder, F. F. Bull. Johns Hopkins Hosp., 1926, 39:371.
42. Seguy, J. and Vinneux, J. Gynéc. et obst., 1933, 29:346.
43. Solal, R. Bull. Soc. d'obst. et de gynéc. de Par., 1932, 21:725.
44. Venning, E. H , and Browne, J. S. L. (a) Proc. Soc. Exper. Biol. & Med., 1936, 34:792; (b) Am. J. Physiol., 1938 123:209.
45. Venning, E. H. Henry, J S., and Browne J. S. L. Canadian M. Ass. J., 1937, 36:81.
46. Whitehouse, B. H J Obst. & Gynæc. Brit. Emp., 1926, 33:607

MY EXPERIENCE WITH THE MELHADO MANEUVER FOR PERSISTENT POSTERIOR POSITION

GEORGE M. WHITE, M.D., M.C.O.G., F.A.C.S., St. John, New Brunswick

THE delivery in persistent posterior position remains one of the most difficult problems in obstetrics. It tests the judgment and skill of the obstetrician as much or more than any other problem in his practice.

The occurrence of this condition seems to vary somewhat in different parts of the world, or at least the statistics issued by different writers vary. In Eden and Holland's textbook, posterior positions are given as 25 per cent of all obstetrical cases. The figures of Douglas Miller, Edinburgh Maternity Hospital, are 18 per cent. Many years ago the late Professor Williams gave the figures from Johns Hopkins Hospital as 11.3 per cent, and Cragin in a large number of cases at the Sloane Hospital gave the figures as 17 per cent. So you see we have here 4 very reliable sources with the figures varying from 11 per cent to 25 per cent. One is inclined to believe that they are more liable to be underestimated than overestimated. As one is employed in this work he finds that he recognizes more and more posterior positions that rotate spontaneously and do not become persistent. It is probably fairly accurate to say 75 to 85 per cent of all posterior positions rotate spontaneously, so that only from 15 to 25 per cent remain as persistent posterior positions or deep transverse arrests.

You will notice from the heading of my paper that I have no intention of discussing posterior positions as a whole. I am fully aware of the fact that this condition is handled by many men in many ways with excellent results. It was my privilege during my years of training at the Royal Victoria Hospital, in Montreal, to learn this method of handling posterior positions. I believe that it is a good maneuver. I hope to show that the results obtained by others using this method, and more recently my own, compare favorably with the results of any other method used. I do not believe this method should be used to the exclusion of every other method, but I do believe in my own hands it is better for me than any other maneuver. I think every man should use the method in which he is most skilled and from which he obtains the best results. So I shall not discuss the etiology of posterior positions nor other methods of delivery, but I shall touch on the methods of diagnosis and the importance diagnosis has on the conduct of labor.

From the Department of Obstetrics, St. John General Hospital.
Presented in the Symposium on Obstetrics and Gynecology before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938

In my own private cases I very often can make a diagnosis of a posterior position during the office visits of the last month. Some of these pregnancies are definitely engaged in a posterior position, and some are not well engaged and arouse one's suspicion, as they will in all probability engage in a posterior position. This is a help in the cases at one's office, but often I am called in consultation by an interne with a public patient or by a fellow practitioner with a private patient of his own. I make it a rule, regardless of the time of day or night, that when a patient is admitted to the hospital in labor, to examine her as soon as possible and make a diagnosis as to the position. I believe that this is very important in planning the conduct of the labor.

If I find a breech in the fundus, the resistant plane of the back well out on the right flank with the small parts of the left side well up in front, and much more readily palpable than in an anterior position, the head not well engaged, the cephalic prominence on the left side, the fetal heart well out in the right flank, or sometimes on the left side just near the midline, then I strongly suspect a posterior position. If on rectal examination the head is high and not well engaged, or if the head is engaged and the sagittal suture felt in the right oblique, then my diagnosis is complete.

They are not all as easy as this. Frequently rectal examinations are not satisfactory. If after a reasonable number of hours of good labor I am in doubt of the diagnosis or have not a clear conception of the position, or of the mechanism of labor that is going on, then, under anesthetic with proper sterile technique, I do a vaginal examination. During this examination I try to decide in what diameter the sagittal suture is lying, where the anterior and posterior fontanelles are, the position of the ears, the condition of the cervix, how much it is effaced, and how much it is dilated, and from this examination I am able to decide whether I have a persistent posterior position.

The character of the labor often leads one to suspect a posterior position which may not have been diagnosed. Many posterior positions go by the expected date. The first stage is often long and drawn out with a poor quality of uterine contractions and excessive pain in the back. The cervix is slow to efface and dilate and the head remains high. A great many of these cases have the membranes rupture early, so that the first stage of a posterior position is a very unsatisfactory part of labor.

In the diagnosis of posterior positions I always warn my students not to be misled by the position of the point of maximum intensity of the fetal heart. In a right posterior this is most often well out in the right flank, but if deflexion has occurred and the fetal chest is thrown well forward and up against the mother's abdominal wall, it may then be heard best on the left side, very much in the position of a left occipito-anterior. However, this should not mislead us. One always has the x-ray to help him, and in cases in which the diagnosis is difficult I have no hesitation in using it.

There is 1 point in regard to the cervix, that I have noticed, which has been a help to me. In anterior positions the cervix, after it is taken up and before dilatation begins, is often very far posterior and hard to reach, whereas in posterior positions this external os is often missed because of the fact that it is so far anterior. So often I have an interne tell me he thinks the cervix is fully dilated because he cannot find the opening, and on rectal examination I find the cervix way up in front almost under the symphysis and not dilated. I have at times missed the diagnosis of a posterior position during the whole of the first stage, until the cervix was fully dilated and the head driven down below the spines, sometimes as a posterior, sometimes as a deep transverse arrest. Then the patient may have strong bearing down pains with the head almost in sight, but showing no pressure on the perineum, no relaxation of the anal sphincter, and without proper progress. This is characteristic of a persistent posterior position.

So I use in the diagnosis of posterior positions, first, abdominal and rectal examination, then a vaginal examination if necessary, and finally the x-ray.

Having made the diagnosis we must now plan the conduct of the labor. During the first stage the patient will require a considerable amount of care and attention. The studied use of sedatives both as to kind and amount is important. As we mentioned before, the first stage of labor in these cases is liable to be long drawn out and unsatisfactory. The patient requires appropriate sustaining treatment as well as sedation. I have found here that the combined use of intravenous glucose and subcutaneous morphine gives excellent results. I think it is important to remember that no interference is justifiable until the cervix is effaced and dilated and the presenting part in the pelvic brim. This is the period of watchful waiting of which we have heard so much.

After these conditions have been fulfilled and the contractions are continuing, but progress has stopped or nearly so for 1½ or 2 hours, it is time to desert our practice of *masterful inactivity* and to interfere, in the interests of the mother and child. If the cervix is not fully dilated but is dilatable and there are signs of fetal distress, it is sometimes necessary to interfere a little sooner than one would if the conditions were better. I think it is just here in the conduct of labor that one has to use his nicest judgment to decide when to interfere and I do not believe there is any one rule that will cover every case, but that as labor progresses and is closely watched, one must decide the most opportune time in the interests of both mother and child.

Dr. DeLee says, "the posterior position itself, and the operations performed because of it, cause untold and untellable maternal and infant suffering—the child's brains are damaged and the mother's soft parts lacerated and destroyed."

The following tables give a review of Dr. Melhado's cases as published by him in 1933.

TABLE I.—GENERAL REVIEW OF MELHADO'S 976 CASES

	Cases	Per cent
Primiparas	513	52.5
Multiparas	463	47.5
Complete tears	71	7.27
Maternal morbidity	249	24.4
Fetal mortality	44	4.5

There were 976 cases of occipitoposterior position delivered during a period of 6 years at the Royal Victoria Hospital, 513 primiparas, and 463 multiparas. There were 71 complete tears; maternal morbidity occurred in 249 cases or 24.4 per cent. The standard of morbidity used was a single rise of temperature to 100.6 degrees, occurring during the puerperium after the first 24 hours. Fetal deaths were 44 or 4.5 per cent. These included stillborn and those that died during the first 2 weeks of life.

The interesting thing to note from Table II is that both the fetal mortality and the maternal morbidity increased with the failure of anterior rotation.

TABLE II.—ANALYSIS OF 392 SPONTANEOUS DELIVERIES*

Procedure	Number	Maternal number	Mortality per cent	Maternal number	Morbidity per cent	Fetal number	Mortality per cent
Anterior rotation	284	0	0	52	18.6	2	.7
Face to pubis	108	0	0	33	30.5	6	5.5

*This represents 40.1 per cent of 976 cases.

TABLE III.—ANALYSIS OF 584 OPERATIVE CASES*

Procedure	Number	Maternal number	Mortality per cent	Maternal number	Morbidity per cent	Fetal number	Mortality per cent
Low forceps	157	2	1.24	37	23.5	4	2.48
Classical midforceps	209	1	.40	58	27.2	16	7.60
Scanzoni operation	67	0	.0	17	25.3	5	7.46
High forceps	44	0	.0	24	55.5	4	11.10
Melhado maneuver	107	0	.0	27	26.1	2	1.80

*This represents 59.8 per cent of 976 cases.

In his summary Melhado has called attention to the following facts: There is a close similarity in the morbidity rate among all forceps operations; the morbidity rate is increased with failure of anterior rotation whether the labor was spontaneous or operative; and the best fetal results, apart from spontaneous anterior rotation and spontaneous delivery, were obtained when the Melhado maneuver was employed.

PROCEDURE

It is our custom not to interfere during the first stage of labor, except by those therapeutic methods which aim at the relief of pain. After complete dilatation of the cervix, labor is allowed to progress naturally as long as the head is advancing rapidly. Failure of the head to advance demands immediate determination of the cause and its correction. It is usual in such cases that we find the membranes ruptured, the sagittal suture of the child's head lying in one or other oblique with occiput behind, or in the transverse diameter of the pelvis. Flexion of the head is, as a rule, imperfect, the head being engaged in the pelvis. There may or may not be undue molding, depending on the duration of the second stage. With the whole hand in the vagina, the perineum and pelvic floor are thoroughly dilated. The entire head is carefully palpated, if necessary, to make a correct diagnosis as to the position, the degree of molding, and the type of head. The head is dislodged completely and pushed up above the pelvic brim. The hand is passed through the cervix beyond the occiput. If any resistance is encountered, such as a contraction ring around the neck, it is carefully "ironed out." The anterior shoulder is palpated and its position determined. If the shoulder appears to be directed forward, it is ignored; if the child's back is found to be directed toward the maternal back, the shoulder is carried forward as far toward the anteroposterior diameter as possible. The head is now placed so that it lies with the sagittal suture in the transverse diameter of the brim, the posterior ear resting in the palm of the hand. The back of the hand will then be lying on the promontory of the sacrum. The posterior blade of the forceps is applied along the palm and placed exactly over the posterior ear, with the pelvic curve toward the occiput. The handle of the forceps is held by an assistant to prevent slipping

TABLE IV.—GENERAL REVIEW OF AUTHOR'S 124 CASES

	Number	Per cent
Primiparas	74	59.7
Multiparas	50	40.3
Complete tears	4	3.2
Maternal morbidity	21	16.9
Fetal mortality	0	

TABLE V.—ANALYSIS OF 124 SPONTANEOUS DELIVERIES

Procedure	Number	Maternal number	Mortality per cent	Maternal number	Morbidity per cent	Fetal number	Mortality per cent
Anterior rotation	62	0	.0	10	16.1	0	.0
Face to pubis	12	0	.0	4	33.3	0	.0

TABLE VI.—AUTHOR'S CASES DELIVERED BY MELHADO MANEUVER

	No.	Per cent
Cases delivered by the Melhado maneuver	50	40.3
Maternal morbidity	7	14.0
Maternal mortality	0	.0
Fetal mortality	0	.0

during the application of the second blade. The hand is then withdrawn, and the anterior blade is carefully passed across the face of the child until it lies over the anterior ear, i.e., directly opposite the first blade. There can be no possible danger of injury to the bladder during this or any subsequent part of the procedure, because all manipulations are done above the brim of the pelvis where there is plenty of room. The forceps are then locked. A gentle movement of 45 degrees rotation is imparted to the forceps, the object of this movement being to bring the occiput to an obliquely anterior position. Every step in the maneuver up to the present time is done with the head free from the pelvic control. The head is now lying within the forceps at the brim of the pelvis, the sagittal suture is in relationship with one of the oblique diameters, and the occiput is obliquely anterior.

With traction, the head is once more brought down into the pelvis. It is astonishing the ease with which the head descends on to the pelvic floor and delivery is accomplished. Usually in this method, the head is brought down in the opposite oblique diameter to that which it originally occupied, i.e., the right occipitoposterior position after rotation to become a right occipito-anterior position and the left occipitoposterior position a left occipito-anterior position (the left hand used in right position and vice versa).

In the delivery of my own cases of posterior positions, the results of which I quote below, I have endeavored to follow this maneuver as closely as possible. Certain criticisms of this method have been offered, in that dislodging the head from the pelvis increases the danger of prolapse of the cord. In neither Dr. Melhado's original cases nor in any of my own did this happen. It has also been pointed out to me that in the application of the forceps above the brim of the pelvis, one is doing a high forceps; but dislodging a head that has engaged and molded, and bringing it back into the pelvis in a corrected position, is entirely different from dragging a head that has never been engaged into the pelvis.

TABLE VIII.—FETAL MORTALITY AT ROYAL VICTORIA HOSPITAL FOR SIX YEARS

Method	Per cent
High forceps	11.1
Classical midforceps	7.6
Scanzoni	7.4
Face to pubis with spontaneous delivery	5.5
Low forceps	3.4
Melhado maneuver	1.8
Spontaneous rotation with spontaneous delivery	.7

TABLE VII.—FETAL MORTALITY RESULTING FROM USE OF VARIOUS METHODS

	Per cent
Cowles	8.06
Dodek	8.33
Cragin	7.66
Hurst	9.00
Green-Armytage	8.00

In conclusion I would like to present two more tables to show a comparison of the fetal mortality results from different methods of delivery of persistent posterior positions.

These are the figures of fetal mortality published by outstanding men in different parts of the world. In Table VIII I present the fetal mortality resulting from different methods of delivery of posterior positions in the Royal Victoria Hospital over a period of 6 years.

My series of cases have been few in number as compared with those of men working in larger places, and they have been scattered over a period of 5 years, and have included both private and public patients. Nevertheless, I think the fact that I have not had one fetal death, speaks well for this particular method of delivery.

REFERENCES

1. Cragin, E. B. Obstetrics, a Practical Textbook for Students and Practitioners. Philadelphia: Lea & Febiger, 1916.
2. Cowles, H. C. Occiput posterior: a case analysis. Am. J. Obst. & Gynec., Nov. 1933, 26.
3. DeLee, J. B. The treatment of obstinate occipitoposterior positions. J. Am. M. Ass., 1920, 75: 145–147.
4. Dodek, S. M. The vertex occipitoposterior position; the treatment of more than 500 consecutive cases. J. Am. M. Ass., 1931, 96: 1660–64.
5. Eden and Holland. Manual of Midwifery. 7th ed., p. 325. New York: The Macmillan Co.
6. Green-Armytage, V. B. The occipitoposterior; its complications and treatment; with observations on the insulin-glucose method in shock. Indian M. Gaz. 1927, 62: 675–680.
7. Melhado, G. C. The occipitoposterior position. Am. J. Obst. & Gynec., Nov. 1933, 26.
8. Miller, D. Occipitoposterior position of the vertex; a survey of 750 cases. Tr. Edinb. Obst. Soc., 1926–1927, 86: 77.
9. Williams, J. W. Obstetrics. 4th ed., p. 285. New York: D. Appleton & Co.

SURGERY ON HANDICAPPED PATIENT

SURGICAL PROBLEMS IN JAUNDICED PATIENTS

ROBERT S. DINSMORE, M.D., F.A.C.S., Cleveland, Ohio

JAUNDICE is a symptom and not a disease entity, and because of this one must decide at its onset whether he is dealing with blood dyscrasia, primary disease of the liver or biliary tract, or a mechanical obstruction.

The history in this condition is always very important to the surgeon. In addition to ascertaining whether the jaundice has been transient or persistent, a knowledge of the absence or presence of pain and its character, particularly in relation to the jaundice, has been the surgeon's chief aid in making a decision in a large number of his operative cases. The history of previous operations on the biliary tract is disconcerting to the surgeon but, if these have been performed, he must know their exact nature and extent, that is, whether the operation was a cholecystostomy or a cholecystectomy. More specifically he must know how long drainage persisted after the first operation and also the time of appearance of the jaundice in relation to operation. It is a privilege to make the first incision in any biliary operation, particularly in the deeply jaundicedp atient.

According to Hartman 25 per cent of all cases of jaundice are due to the gall stone or associated conditions (30 per cent in our own experience), and 30 per cent to carcinoma, either of primary or metastatic nature in the region of the pancreas and ducts. It is also significant that in only 25 per cent of the cases, including both toxic and infectious, is the jaundice due to lesions of the parenchyma of the liver. From these figures, it must be concluded that even a conservative estimate indicates that exploration should be performed in well over one-half of all patients with jaundice. Bitter experience has taught the surgeon that, due to the ever increasing number of drugs in use today, toxic hepatitis should also be considered as a possible cause of jaundice.

Hemolytic jaundice can not be discussed except to state that careful studies of the blood should rule out this possibility. Associated stones, however, may be a complicating factor causing either cholecystitis or obstruction of the common duct.

From the Cleveland Clinic.
Presented in the Symposium on Surgical Procedures on the Handicapped Patient, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

It is unfortunate that cholecystography is contra-indicated in jaundiced patients. Occasionally, however, a flat plate of the right upper quadrant of the abdomen may be of great assistance in arriving at a diagnosis. The radiologists have stressed the point that these plates should be taken with at least 2 or 3 different penetrations and with the bowels completely evacuated.

In spite of all the refinements in diagnosis, the surgeon still sees certain cases in which an exploratory operation must be done to determine the true cause of the jaundice. In 2 instances during the past year, even after the most complete and exhaustive studies, I have operated and found that each of the patients had a very small atrophic liver which caused the jaundice.

PRE-OPERATIVE PREPARATION

In general surgery it is becoming increasingly obvious that in many cases of chronic illness requiring surgery, adequate pre-operative periods of preparation are essential. It is no longer good surgical judgment to send such patients into the hospital one day and operate the following day. The lowered mortality rates following the use of a careful pre-operative routine in many special fields bears testament to this fact, which was probably first emphasized by the men doing thyroid and genito-urinary work. Many lesions of the gastro-intestinal tract, such as dilatation of the stomach, chronic obstruction, and all conditions of the colon, as well as many cases of chronic disease of the chest, were formerly considered as emergencies, but now the patients are prepared for operation over a period of several days. This is particularly true of the jaundiced patient if a low mortality rate is to be maintained. Unquestionably, this factor has been more important than improvement in operative technique. Ordinarily it requires from 4 to 7 days and, as a general rule, it is better to extend the pre-operative period than to shorten it if the patient is improving.

The surgeon is primarily interested in the degree of liver damage which has taken place, for he recognizes that a chronic infection of the intrahepatic ducts must be considered as an almost

constant factor in obstruction accompanying choledocholithiasis. The surgeon wishes to know specifically the following points about the patient upon whom he is to operate: (1) the function of the liver; (2) the level of the serum bilirubin; (3) the coagulation time of the blood; (4) renal function studies; (5) the roentgen findings in the flat plates of the right upper quadrant; and (6) if a postoperative fistula is present to have cholio-graphic studies.

We know that patients who are suffering with jaundice have a tendency to bleed after operation but, as Mason has stated, no test has yet been devised which can be relied upon to indicate that postoperative bleeding will not occur. Although there is some controversy as to whether the lack of available calcium is one of the factors in this hemorrhagic tendency, I still feel that the administration of calcium should be a part of the pre-operative routine. We are indebted to Lee and Vincent, Whipple, and Walters particularly for repeatedly emphasizing this precaution and recommending that 5 cubic centimeters of the 10 per cent solution be given each day during the entire pre-operative period.

Unquestionably the most important pre-operative procedure is the transfusion of blood, at least 2 transfusions of 750 to 800 cubic centimeters each being required. Following this treatment, the direct beneficial effect is apparent by improved appearance in the general condition of the patient and the lowered coagulation time of the blood.

The factor of dehydration must also be borne in mind. This can be remedied by the use of a 10 per cent solution of glucose in normal saline, given either subcutaneously, intravenously, or both as necessity dictates. The diet should be rich in carbohydrates. Ordinarily we encourage these patients to eat large quantities of hard candy. It is not within the scope of this paper to discuss the so called liver deaths, but Graham's work is strong evidence that the chief factor in the prevention of this catastrophe is an adequate store of glycogen.

In the light of the recent work of Snell and his coworkers, estimations of the prothrombin level and the prothrombin time will undoubtedly be added to the pre-operative routine as will the treatment with the newly isolated vitamin K which has a marked effect upon these jaundiced patients who have a deficiency of this substance.

TESTS OF LIVER FUNCTION

The tests of liver function are generally unsatisfactory because the liver has such a large reserve that even quite marked structural changes do not produce an alteration of function as gauged by the tests now in use. The tests we have used are: (1) bromsulphalein retention in plasma after intravenous injection; (2) galactose tolerance test if jaundice is present; (3) Takata-Ara test in blood and in ascitic fluid in the presence of ascites; (4) special blood studies to determine the volume and shape of the red blood cell and the degree of anemia; and (5) determination of total blood protein.

The bromsulphalein test is the most sensitive of all tests now in use but it is not satisfactory in the presence of obstructive jaundice. The galactose tolerance test is not a sensitive one and has little practical application in liver disease. The excretion of galactose may be impaired if the jaundice is due to liver disease but the test gives normal findings if the jaundice is due to simple obstruction.

The Takata-Ara test is positive in a number of types of liver disease but is most frequently positive in cirrhosis, a negative test being strong evidence against the presence of cirrhosis. If ascites is present and the test is positive in the ascitic fluid, the accumulation of fluid can usually be attributed to cirrhosis. These same observations are true in regard to the determination of the total blood proteins.

If there is liver damage, anemia is a common finding. Here the red cell is nearly always larger than normal so a macrocytosis of the red cells is suggestive of disease of the liver parenchyma. If there is obstructive jaundice due to disease of the bile ducts, a flattening of the red cells occurs without an increase in volume.

The change in the red cells seems to be the most sensitive index of liver function but these studies must be repeated frequently to be of clinical significance. The most useful test is the bromsulphalein test. The Takata-Ara test is simply done and may give valuable information.

Surgeons are often confused by the various methods used in determining the coagulation time in severely jaundiced patients. In our experience, all stab and puncture methods have been considered to be unreliable due to the fact that the blood has been squeezed through the tissues. For that reason we have discarded all such procedures and use routinely the White and Lee method which requires 5 cubic centimeters of venous blood, 1 cubic centimeter being placed in each of five 8 millimeter tubes. The first tube is tipped at 4 minutes and the others at the same interval. If the coagulation is not complete in 5 to 8 minutes it is considered abnormal, thus giving an actual

accurate coagulation time. A knowledge of the bleeding time has not been of much clinical assistance.

Cholangiography. Cholangiographic studies will undoubtedly come to be recognized as a definite adjunct in the management of a certain number of patients with fistulas and persistent jaundice. A large bibliography has been accumulated on the subject, and Best and Hicken within the past few years have emphasized its use and importance, either as an immediate procedure at the time of operation, or postoperatively when a fistula is present or a T tube is in place. In certain cases there is some question at the time of operation as to the cause of the obstruction. From their studies these writers have shown that an occluded cystic duct may be the cause of the rather high mortality rate and of some of the failures following a cholecystostomy or cholecystogastrostomy in jaundiced patients. It is not indicated, however, as a routine in the uncomplicated cases. If these plates can be taken while the patient is on the operating table and the opaque substance passed into the gastro-intestinal tract without obstruction, the abdomen may be closed with complete assurance of the patency of the common duct. They believe that cholangiography reveals many stones which could not be felt by palpation or direct visualization. In individuals who have had drainage with a T tube or who have a persistent fistula, cholangiography is undoubtedly of great value in showing the presence of the choledochal stones, strictures, or tumors.

Cholecystostomy or cholecystectomy. Cholecystostomy still has a definite place in the handling of deeply jaundiced patients. True it is that the field is limited, but no hesitancy should be shown in doing a cholecystostomy in a severely ill, elderly patient with a rapidly developing jaundice. When a stone has become impacted in the ampulla, the stone may be seen occasionally in a small pouch at the neck of the gall bladder. It is often accompanied by acute inflammation of the surrounding area, acute cholangitis, and an empyema of the gall bladder. In several such cases the removal of the stone and cholecystostomy have been lifesaving measures. Likewise, in a severely ill patient with jaundice and stones in the common duct and the gall bladder, it may be unwise to perform a cholecystectomy instead of draining both the gall bladder and the common duct. I believe that it is a dangerous dictum to state that a cholecystectomy is always indicated. One of the striking features about some of these cases is a marked thickening and edema of the serosa of the gall bladder. For many years one of my associates, Dr. William E. Lower, has used a modified cholecystectomy in this group of cases. After opening the dome of the gall bladder and removing the stones, a line of cleavage between the serosa and the mucosa is easily delineated and the mucosal surface stripped out, which at times looks almost like a cast of the gall bladder. This procedure in the proper case has the advantage of being done quickly without leaving a raw, bleeding surface on the liver bed. Dr. Lower has never been obliged to do a secondary operation on any of these patients, and he is favorably impressed by the little postoperative reaction which these patients experience.

The indications for cholecystectomy are well understood. The operation in the deeply jaundiced patient depends upon the local inflammatory reaction and the general condition of the patient. Most surgeons agree that the best type of drainage, after removal of the stones in the common duct, is secured with a T tube, the limbs of which have been shortened and a notch placed on the posterior side so that it can be removed easily. This has been far more satisfactory than the insertion of a straight catheter toward the liver, attempting to sew it and hold it in place with sutures. Undoubtedly these catheters have, on occasion, unknowingly been inserted in the distal side. It is also much easier to approximate the duct accurately about the T tube than around a straight catheter.

The short-circuit operations of the gall bladder to the stomach or duodenum, on the whole, have been unsatisfactory. If possible, it is preferable to anastomose the gall bladder to the duodenum rather than to the stomach. If the anastomosis functions properly, it often gives relief from the intolerable itching of which the patients complain; and quite frequently immediate relief is secured from the deep, boring pain which the patient with a chronic pancreatitis or carcinoma of the pancreas experiences. The opening need be only a small one, and in the deeply jaundiced patients we have felt that silk may be used to advantage on the serosal surface. In doing the operation it is a great comfort to see colored bile returning from the gall bladder after the thick tenacious material has been evacuated. Oftentimes it is difficult in some of these cases, even with adequate exposure, to know whether you are dealing with an inflammatory or a neoplastic process.

Best and Hicken have pointed out that the high mortality in these patients has been due to the obstruction caused by the inflammation, neoplasm, or stone which has been overlooked, and

this of course is a forceful argument for the use of cholangiography while the patient is on the table.

OPERATIVE PROCEDURE

I feel that in my own hands gas-oxygen anesthesia augmented by ether has been most satisfactory. We are concerned with an anesthetic which can be given with a minimum of damage to the liver and at the same time give adequate relaxation. Any type of deep anesthesia, particularly with severely jaundiced patients, is to be avoided. I have used spinal anesthesia occasionally but still prefer not to use it in the upper abdomen, although it may be of advantage in secondary operations upon the common duct.

Incisions for gall-bladder work are largely a matter of choice. It is always interesting to note that most surgeons, after trying all the different approaches, usually return to the right rectus incision. In this connection one point has been a particular help to me and that is in being careful that the incision is high enough. Dr. Judd always placed particular emphasis upon the importance of carrying the incision as near the costal border as possible. In general, it can be stated that surgery of the deeply jaundiced patient is for the most part difficult. Lord Moynihan stated that the surgery of cholelithiasis as a general problem was difficult, sometimes extremely difficult; and he held it to be of greater technical difficulty and to present more problems for accuracy of judgment than any other branch of surgery. This is particularly true in the obstructive case of jaundice which is either persistent or has occurred after a surgical procedure. One always hopes that it is due to stones in the duct and not to a stricture or injured duct. A great deal of emphasis has been placed on the various types of anastomoses, either on repair of the duct or its anastomosis to the gastro-intestinal tract. Little emphasis has been placed on the isolation of the structures with which to do an anastomosis. After all, the great difficulty is in finding the proximal side of the injured duct. Unquestionably, the ideal procedure is to anastomose this to the duodenum and not attempt any plastic surgery on the duct itself.

POSTOPERATIVE CARE

From this discussion it is quite evident that the pre-operative care of these patients is of primary importance if they are to have a smooth postoperative convalescence and avoid the complications so common in the unprepared, jaundiced patient. There are a few points that may be mentioned about these patients after operation. It is important at the onset to be prepared to do a transfusion at any time and to have adequate donors available. Occasionally bleeding may occur 8 to 12 days after the operation in a patient who is apparently doing well. With this in mind, measures to combat the hemorrhagic tendencies should not be discontinued too soon. In most instances it is advisable to do a transfusion immediately after the operation. Ordinarily these patients are much more comfortable in a semi-Fowler's position and when given continuous intravenous glucose and saline solution for the first 24 to 48 hours. This insures an adequate intake of carbohydrates and fluids. Many of these patients are more comfortable in an oxygen tent for the first 24 hours after the operation and, in addition to the easier respiration, the general appearance of these deeply jaundiced patients is improved. If a T tube has been inserted, it is advantageous to clamp the tube for 1 or 2 hours at a time as soon as possible, oftentimes on the third day, to prevent an abnormal loss of bile. The question as to when the T tube is to be removed rests largely with the individual case for it will likely be an established routine to do a cholecystogram on many of these patients before the tube is removed. The tendency now is to leave these tubes in longer than formerly.

CONCLUSION

These cases then represent a group who present definite difficult problems in diagnosis and operative technique; and if a low mortality rate is to be maintained, they must be handled as bad risks, carefully prepared before and carefully watched after operation.

REFERENCES

1. Best, R. R., and Hicken, N. F. Cholangiography. Surg., Gynec. & Obst., & Internat. Abstract Surg., 1938, 66: 126–131.
2. Graham, E. A., Cole, W. H., Copher, G. H., and Moore, S. Diseases of the Gall Bladder and Bile Ducts. Philadelphia: Lea & Febiger, 1928.
3. Hartman, H. R. A study of the cause of jaundice in 400 cases. Med. Clin. N. America, 1928, 11: 1383.
4. Lee, R. I., and Vincent, B. The relation of calcium to the delayed coagulation of blood in obstructive jaundice. Arch. Int. Med., 1915, 16: 59–66.
5. Mason, R. L. Pre-Operative and Postoperative Treatment. Philadelphia: W. B. Saunders Co., 1937.
6. Snell, A. M. Symposium on hemorrhagic diathesis in cases of jaundice; its relation to vitamin K deficiency. Proc. Staff Meet. Mayo Clin., 1938, 13: 65–67.
7. Walters, W. Pre-operative preparation of patients with obstructive jaundice. Surg., Gynec. & Obst., 1921, 33: 651–656.
8. Whipple, A. O. Surgery of the biliary tract. Surg. Clin. N. America, 1921, 1: 373–389.

MEDICAL ASPECTS IN PRE-OPERATIVE AND POSTOPERATIVE CARE OF DIABETIC AND CARDIAC PATIENTS

JAMES E. PAULLIN, M.D., Atlanta, Georgia

IN APPROACHING an understanding of what is to be and what can be accomplished in patients with diabetes mellitus or heart disease, from a medical point of view, it is necessary to have a clear understanding of the problems involved based on physiological, physical, and chemical facts, in order to justify any form of therapy. It is known that these disabilities increase the hazard of surgical procedures, but these hazards can be greatly diminished if there is a definite understanding of the existing condition by those who are vitally concerned in the success of a completed program.

I wish to stress the importance of a complete understanding of the problems involved in these handicapped patients by the anesthetist, the internist, and the surgeon. Working co-operatively, they offer the greatest security to these patients. In my opinion the anesthetist is not only a very necessary member of this group, but one to whom the internist and the surgeon look for help. He should be a well trained physician who has devoted time and study to his specialty and who has had sufficient clinical experience to detect and to evaluate correctly changes occurring in a patient during anesthesia. From his training and experience he is capable of advising the anesthetic of choice and the degree of anesthesia to be produced. What a comfort such an anesthetist is to the surgeon whose mind is free to perform the necessary operation as expeditiously as possible with a minimum of trauma, and to the internist who knows that his physicially handicapped patient is in the hands of an understanding person. With such a group, surgical problems are approached with greater confidence and safety which otherwise are unobtainable.

Ordinarily patients with diabetes and those with heart disease present for solution problems which are in nowise related. After 50 years of age both groups develop mutual problems. It is generally known that patients with diabetes are much more likely to develop arteriosclerosis and its complications than an equal number of patients of the same age group with other diseases. After 50 years of age the number of patients with heart disease seeking surgical relief will be found to have impairment of their circulatory mechanism, most frequently because of arteriosclerosis. The diabetic offers the greatest difficulty of these 2 groups because he has not only diabetes but also arteriosclerosis, whether the latter is demonstrable or not.

From the Medical Department, Emory University.

Presented in the Symposium on Surgical Procedures on the Handicapped Patient, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

PATIENTS WITH DIABETES MELLITUS

The mild diabetic requiring immediate surgery becomes a patient with a potentially serious handicap, the seriousness depending upon the nature of the disease requiring surgical relief. Infection of any kind is most dreaded in a diabetic because it not only makes his disease worse but if uncontrolled leads to acidosis, coma, and death. It is most essential, therefore, for the patient and the internist to recognize the onset of infection at the earliest possible moment, and if amenable to surgical relief, to seek this as promptly as possible. Prompt treatment of infection helps the diabetic to rid himself more quickly of a pathological lesion which makes his disease worse. With our present knowledge of diabetes, our expert physician anesthetist, and with such wonderful surgical skill and experience in treating infection, the diabetic mortality from this cause should greatly decrease, provided we teach our patients to seek help early.

In acute surgical emergencies, arising during the course of diabetes, too much stress cannot be laid upon the necessity of quick operative relief. Delay in seeking this relief may, and frequently does, forfeit whatever chances the patient has for complete recovery.

PRE-OPERATIVE CARE

Those diabetics who do not require emergency surgery present certain problems of importance in their pre-operative preparation. The object of such care is to obviate the possibility of acidosis, to prevent other complications which might arise, and to hasten convalescence. In the care of pa-

tients belonging to this group there are certain considerations which are of value in order to accomplish the desired results:

1. To store glycogen in the body sufficient to supply the patient's needs during the period of operation and for several hours thereafter. This is accomplished by feeding, in the previous 24 hours, at least 150 grams of carbohydrate and by controlling glycosuria by the administration of insulin in the necessary dosage at 2, 3, or 4 hour intervals.

2. Giving a sufficient amount of fluids to take care of the body needs which ordinarily would amount to 2,500 or 3,000 cubic centimeters, administered as water, broths, fruit juices, oatmeal gruel, tea or coffee, etc.

3. It is desirable to administer easily assimilable foods in the form of carbohydrate until at least 4 hours before the time of operation.

4. The established dose of insulin is continued without regard to the operation, the only difference being a change in the time of administration. If a diabetic is receiving protamine insulin, and most of them are, this should be continued and supplemented when necessary with small doses of regular insulin every 3, 4, or 6 hours as the occasion demands. The dose required is determined either by the presence of sugar in the urine or an increasing blood sugar.

5. If the diabetic is an individual who is not under good control, it is far better to have, if time permits, dietary and insulin adjustment before operation is undertaken. The diabetic is much safer if he goes to the operating room with a urine sugar-free and a blood sugar which approaches normal.

6. In acute surgical emergencies, which are usually accompanied by marked acidosis, as evidenced by a lowering of the carbon dioxide combining power of the blood plasma, and the detection in the urine of diacetic acid as well as glucose, the immediate needs of the patients must be met by giving a sufficient amount of regular or quick-acting insulin, the administration of normal salt solution subcutaneously or intravenously, cleansing the lower bowel with an enema, and washing the stomach with plain water. Such treatment followed in a regular and orderly manner over a period of a few hours will diminish the operative hazard and promote recovery.

Little Mary Jane, a well trained diabetic 10 years old, living in a neighboring town, developed an acute otitis media. The ear drum was promptly punctured by her physician but fever continued, glycosuria increased, and the infection spread so that 36 hours later the mastoid was involved. Despite increasing doses of insulin, sugar and diacetic acid excretion steadily mounted, and rather quickly she developed a marked acidosis. She entered the hospital with a temperature of 104 degrees F., marked tenderness over the right mastoid, and a thin purulent discharge from the right ear. The urine contained 4.8 per cent of sugar, the blood sugar was 383 milligrams per cent and the carbon dioxide combining power of the blood plasma was 20 volumes per cent. She was given larger doses of insulin subcutaneously and immediate preparation made for operation. Her stomach had previously been washed and she had received an enema before entering the hospital. It was only necessary to give her salt solution by hypodermoclysis, which was continued during the operation. A mastoidectomy was done under nitrous oxide, oxygen, and local anesthesia. Within 3 hours after her arrival in the hospital she had received treatment for her infection and her acidosis and within 3 days was well on her way to an otherwise uneventful recovery.

7. In so far as possible it is extremely beneficial to allay the fear and anxiety of operation in patients who are afflicted with diabetes by the preoperative administration of suitable doses of the barbiturates and also, when it is found necessary, the use of small doses of an opiate with scopolamine. In my experience, this procedure has been most valuable and has been a great comfort, not only to the patient but to the anesthetist and surgeon as well.

POSTOPERATIVE CARE

In dealing with this phase of the discussion I feel it necessary to direct attention to 4 problems: (1) Upon the return of the diabetic to his room he should at once receive fluid, preferably normal salt solution containing 2.5 per cent of glucose, administered subcutaneously, and if not contraindicated by the nature of the operation, at least 500 cubic centimeters of salt solution by rectum. (2) The patient should be given small but frequent doses of regular insulin, the size of the dose and the frequency of administration depending upon the severity of the diabetes and the patient's preoperative condition. (3) Every attempt should be made to begin feeding the patient by mouth as soon as possible after operation. Our experience has demonstrated that it is possible to start this in the great majority of patients within 4 to 6 hours after the return of the patient to his room. Such foods as oatmeal gruel, ginger ale, fruit juices, tea or coffee with glucose, and crackers are given. Within the first 24 hour postoperative period an attempt should be made to furnish at least 100 grams of glucose either subcutaneously or by mouth, with a sufficient quantity of insulin to keep the urine approximately sugar-free. (4) Constant stock taking and supervision of the sugar metabolism by employing frequent urinalyses and occasional blood-sugar determinations are most essential for the intelligent handling of these patients.

PATIENTS WITH HEART DISEASE

It has been customary among the laity and among physicians to suppose that in perfectly normal individuals, anesthesia in particular and surgical operations in general, impose a terrific burden on the heart and circulation. Such an assumption most likely arose as the result of impressions received in the early days when the administration of an anesthetic, usually ether, was accompanied by marked excitation, struggling, periods of apnea, cyanosis, increase in blood pressure, and increase in heart rate. Thanks to the introduction of more modern methods of preoperative care, to the great advancement of the science of anesthesia, and the entrance into this field of skilled anesthetists, most of the alarming and distressing reactions observed years ago have disappeared. Generally speaking, there was greater apprehension because of the anesthetic than there was of the surgical operation. At the present time it is believed that the properly administered anesthetic throws no additional burden on the heart. We are also of the opinion that when such aforementioned alarming and distressing reactions occur, the modern surgeon attributes them, not to the anesthetic but to the lack of skill of the anesthetist.

In patients with heart disease, irrespective of the type, before advising surgical intervention it is necessary for the internist to know more about the condition of the heart muscle than the type of heart lesion he has. The internist therefore wants to know if the crippled heart is able to function as a good working pump; how much of a load it is now carrying and how much of an increase it will be able to take without showing evidence of fatigue, how much reserve strength the heart has which will be available in the event there are extra demands for its use, and how such facts can be determined beforehand.

To secure such information, must we depend on physical examination, on various instruments of precision, or are we to use these only as confirmatory evidence of facts which have been elicited from a careful history as to what the patient can do without producing discomfort? In arriving at an intelligent decision concerning the reserve strength of the heart, it is necessary to inquire of the patient how much physical activity he can undergo without producing uncomfortable sensations.

Such questions are directed to determine the functional capacity of the left rather than of the right ventricle, since obviously in the majority of patients, except those with mitral stenosis, the left ventricle will be the first to show evidence of weakness. We, therefore, inquire if the patient is able to walk several blocks or to climb several flights of stairs at a reasonable pace, or to walk up a hill, or run a short distance for a street car without producing difficult breathing. Is he able to hold his breath for 40 seconds without discomfort? Can he sleep on 1 pillow? Does he have paroxysmal attacks of dyspnea? If these simple measures are carried out, together with a careful physical examination and such laboratory procedures as are indicated and it is found that the patient is able to undergo the usual exercise tests without respiratory distress, we are reasonably certain that he can undergo a surgical operation without increased danger.

In judging of a patient's heart condition it is important to bear in mind that there is considerable difference between heart disease and heart failure. A patient may have evidence of heart disease yet his myocardium is capable of performing as much work as though his heart had no disease. There is a group of patients with heart disease who, in so far as it is possible to tell, present questions for solution which cannot always be answered with any degree of certainty. I refer to the group with such diseases as angina pectoris, syphilitic aortic insufficiency, aortic stenosis, and complete heart block. It is well known that patients with these disabilities are those who are subject to sudden death. This is a frequent occurrence and such catastrophes are impossible to foresee or foretell even after a most careful history, physical examination, and the use of other laboratory procedures. For this reason it is impossible to predict the effect of surgical operations on this class of patients. Whenever they are subjected to operation it should be understood that the risk is considerable, irrespective of the fact that the heart is functioning satisfactorily at the time.

Patients with irregular action of the heart, if this be due to an occasional premature beat, cause very little or no concern. If the premature beats occur frequently and especially if they are increased after exertion, this should cause us to bear in mind the possibility of developing ventricular tachycardia.

Patients with auricular fibrillation, in the absence of congestive heart failure, will stand operations remarkably well. If the heart is totally irregular but contracting at a fairly normal rate without a marked pulse deficit, there is little danger. In those patients with great irregularity and a marked pulse deficit, the operative hazard is considerably increased because they will give evidence of poor cardiac function. If permissible,

preliminary digitalization will markedly decrease the operative risk.

Hypertension occurring in patients with good cardiac function, without symptoms of angina pectoris, and with a normally acting heart, is no contra-indication for surgery. The usual preoperative preparation of this class of patients for surgery is quite efficacious in preventing the former transient rise in blood pressure which in times past was so frequently seen.

Patients with mild congestive heart failure, as determined by finding fine râles at the bases of both lungs, will undergo operations with less risk if there is ample time for bed rest and digitalis, with consequent improvement of cardiac function before operation. In those patients with marked congestive failure, as evidenced by orthopnea, edema, congestion at the bases of both lungs, and enlargement of the liver, only acute surgical emergencies should be considered. Any operation on this class of patients should be done with the idea in mind that whatever procedure was adopted would have to be predicated upon the theory that surgical intervention gave the patient a better chance of living than if he were denied such relief. Should no emergency exist, improvement of the heart action by enforced bed rest, limitation of fluids, promoting urinary excretion, and the administration of digitalis and other helpful drugs is indicated.

The preliminary digitalization of patients with heart disease, who have good cardiac function, before undergoing surgical operations, in my opinion, serves no good purpose. A heart which functions normally is a good heart surgically and no drug administered before operation will improve this; however, it might be stated that sometimes in elderly patients with arteriosclerosis, small doses of digitalis given 2 or 3 days before operation may be definitely beneficial; but in this group of patients one should always be careful not to produce digitalis intoxication. It is the experience of most cardiologists that the arteriosclerotic group is rather susceptible to digitalis effects.

Medical emergencies which may arise during the administration of an anesthetic or after the return of the patient to his room are such conditions as auricular fibrillation, paroxysmal auricular tachycardia, and premature beats. As a rule these should give very little concern since they are usually transient in nature and tend to subside. Should they persist, the use of vagal compression, digitalis, or quinidine sulphate is quite helpful. Patients with ventricular tachycardia offer a most serious problem. This occurs usually in those with rather marked arteriosclerosis and who have degenerative changes in the myocardium. Treatment with quinidine sulphate is advocated and should be tried. It has proved beneficial on numerous occasions.

It is not my intention to discuss peripheral vascular collapse. As all know, this is not due to heart disease but is a collapse of the vasomotor mechanism, producing shock. Treatment directed to the heart is of no use whatsoever but on the other hand is more than likely to do harm. Well known measures for increasing the blood volume such as immediate transfusion of blood, intravenous salt solution, etc., are the accepted forms of treatment.

POSTOPERATIVE CARE

After completion of the operation in those with heart disease, attention should be directed to the prevention of conditions which might cause some embarrassment to the circulation. Chief among these are abdominal distention, postoperative vomiting, straining at stool, and allowing patient to remain in 1 position too long. Simple measures are always available for meeting such situations without throwing any unusual strain on the heart.

I wish to direct attention to 1 phase of the postoperative care of patients with heart disease and even those without this condition, which I see so commonly abused, and that is the administration intravenously of large amounts of fluids, either as salt solution or salt solution containing rather high percentages of glucose, within a short space of time. The fact is lost sight of that attempts to increase rapidly the volume of the circulating blood throw an additional burden on the heart, and that the administration of concentrated solutions of glucose temporarily disturbs the osmotic balance of the blood. Should it become necessary to give fluids intravenously to this group of patients, it is a much better procedure to administer small amounts at frequent intervals than it is to introduce a large volume into the circulation in a short space of time; furthermore, it is better to furnish fluids subcutaneously rather than intravenously.

At times it is necessary to give solutions of glucose intravenously. These are best given in a 50 per cent solution in amounts of 30 to 40 cubic centimeters and repeated frequently rather than administering a large volume at any 1 time. One should bear in mind that it is a rather hazardous procedure to disturb the osmotic balance of the blood by the sudden introduction into the circulation of concentrated solutions in large volumes.

SUMMARY

In this discussion it has been impossible to refer to all of the conditions which might arise in a given patient. However, I feel that if I have been successful in directing attention to the fact that the care of a patient affected with diabetes mellitus and the care of a patient suffering from heart disease is not a problem which can be handled to the greatest good of the patient by any one individual, but that the existence of co-operative team-work between the anesthetist, the internist, and the surgeon will lead to the greatest number of successes and the fulfillment of a completed program, my effort will not have been in vain.

SURGICAL PROCEDURES IN THE PRESENCE OF DIABETES MELLITUS

LELAND S. McKITTRICK, M.D., F.A.C.S., Boston, Massachusetts

ANY discussion of the surgical procedures upon diabetic patients must presuppose an understanding of the surgical problem of the patient, of the effect of the metabolic disease upon the patient himself, and of its effect upon the course, treatment, and progress of the surgical complication. Successful management of this complication will demand careful co-ordination of this knowledge together with the proper selection of an anesthesia, an operative procedure planned and carried out with particular reference to the individual patient, and meticulous attention to the details of pre-operative and post-operative care. Even then let no one feel that the patient with diabetes can be operated upon with the same degree of safety as the patient without this disease.

EFFECT OF DIABETES UPON THE PATIENT AND HIS SURGICAL DISEASE

In considering the surgical problem of a given patient we too often think in terms of the patient's metabolic disturbance, of its control during operation, and of the postoperative period. Too little do we consider the fundamental fact that this patient has had diabetes. Diabetes, controlled or uncontrolled over a period of years, will result in varying degrees of arteriosclerosis. Too often have we seen a diabetic patient die suddenly from an unsuspected coronary thrombosis or be stricken with some other manifestation of cardiovascular disease not to be impressed with the significance of this complication. It is undoubtedly this arteriosclerotic background which has prompted Dr. Joslin to say, "A diabetic patient is as old as his age plus the duration of his diabetes."

Moreover, the patient is further handicapped by the effect of his metabolic disease upon his surgical complication and its management. Careless or inexperienced care of the diabetes may result in a continued glycosuria, possibly coma; it will increase the incidence and severity of infection, and may interfere with the healing of surgical wounds. Overzealous treatment, on the other hand, may result in insulin shock which, in the case of the older patient with cardiovascular disease, may be very serious.

Experience would suggest that in the controlled diabetic a clean surgical wound will heal in a manner comparable to a similar wound in a non-diabetic of similar age. On the other hand, experience also tells us that the patient with diabetes is more susceptible to infection; that tissue necrosis is more frequently seen and is more extensive when present; that infection makes the diabetes more difficult to control; and that the infection itself is more difficult to eradicate in the diabetic than in the non-diabetic patient. The past as well as the present of every diabetic patient facing a surgical procedure must be given careful consideration in any contemplated surgical undertaking.

PRE-OPERATIVE AND POSTOPERATIVE CARE

Careful consideration is essential to the satisfactory management of surgical patients with diabetes mellitus. There must be a surgeon interested in the care of these patients to take responsibility for the surgical aspects of the problem. In addition there must be an internist of wide experience in the care of diabetic patients to assume charge of the pre-operative preparation and postoperative care of the medical aspects of the problem, and also an experienced anesthetist to assure the selection and administration of the anesthetic indicated for this particular patient. This should not be interpreted to mean that the surgeon is devoid of responsibility in the preparation of the patient for operation; for, after all, his experience in the specific surgical procedure contemplated should be available to the internist and the patient both in preparation for the operation and in the care of the patient after operation. In other words, close co-operation for a common end is essential for the best interest of the patient.

May I summarize in a few paragraphs what one might call the medical observations of a surgeon:

1. For an operation of election the patient should go to the operating room well fed, his liver stocked with glycogen, acid free, and with no more than a trace of sugar in the urine. These are important points.

Presented in the Symposium on Surgical Procedures on the Handicapped Patient, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

2. An emergency operation may be done in the presence of acidosis if the urgency of the condition justifies the increased risk which this incurs. It must be recognized, however, that the presence of acidosis may well restrict the extent of the surgical procedure and the selection of an anesthetic, and puts a much greater burden upon the medical consultant.

3. It is unnecessary and dangerous to attempt to render the urine sugar-free within 3 days after operation. So far as I know there is no evidence that a moderate elevation of blood sugar to 180 milligrams per cent or the presence of a decreasing amount of sugar in the urine for 4 or 5 days after operation in any way interferes with the healing of a clean surgical wound.

4. Insulin dosage based on urine tests is simple and safe provided the doses are small, that the patient is emptying the bladder, and that hypoglycemia is guarded against by occasional blood sugar determinations as soon as the urine is sugar-free.

5. If intravenous glucose is given, it is dangerous and unnecessary to attempt to utilize all the glucose given by an estimated dose of insulin. It is even more dangerous to give insulin for the glucose which usually spills over in the urine after an intravenous injection. We have seen hypoglycemic reactions follow this procedure repeatedly. It is my belief that if intravenous glucose is to be given, it is safe to give insulin according to the urine passed just before the administration of the intravenous solution, and to disregard the glucose given intravenously and discard the first specimen of urine passed following the glucose injection. If in doubt, it is better to give glucose under the skin and to avoid its intravenous use.

6. Failure to recognize a marked increase in carbohydrate tolerance following the removal of an infected leg or drainage of a carbuncle or large abscess is a frequent source of hypoglycemic reaction.

SELECTION OF ANESTHESIA

Theoretically the ideal anesthetic should be one with little or no effect upon the diabetic state; it should not be toxic to the liver or kidneys, and should not be associated with anoxemia. From a practical point of view, however, the anesthetic for a given surgical procedure will depend upon: (1) the surgical problem; (2) the age, duration and severity of the diabetes, and the general condition of the patient; (3) the experience and skill of the anesthetist; and (4) the experience of the medical man in the care of surgical diabetic patients. Regardless of other factors, the anesthetic selected must be one which will permit the surgeon to complete the operation indicated in a minimum of time, with a minimum of trauma and a maximum of safety. Without going into detail, we may summarize a few of the more important facts from the literature and our own experience with the more commonly used anesthetics as follows: Ether causes hyperglycemia, acidosis, and is toxic to the liver.[1] Nevertheless, it is frequently our anesthetic of choice in operations in the lower abdomen.

Chloroform is too toxic to the liver, has all the disadvantages of ether, and we never use it.

Nitrous oxide and oxygen, ethylene oxygen, or cyclopropane and ether in conjunction with novocain block of the abdominal wall is our choice of an anesthesia for operations upon the gall bladder and stomach. If nitrous oxide and oxygen are used, great care must be taken to avoid cyanosis. Enough ether should be added to make respirations easy and permit good color.

TABLE I.—OPERATIONS UPON PATIENTS WITH DIABETES MELLITUS AT THE NEW ENGLAND DEACONESS HOSPITAL

Region of operation	Major	Minor	Total	Deaths
Tongue, face, ear, and eye—carcinoma	2	4	6	0
Skin—carbuncles	71	0	71	4
Skin—abscess	0	100	100	8
Skin—other causes	3	14	17	0
Breast	10	4	14	0
Neck	6	2	8	0
Chest	3	0	3	0
Stomach and duodenum	5	0	5	2
Small intestine	2	0	2	0
Appendix	38	0	38	2
Large intestine	24	0	24	4
Rectum	12	19	31	1
Gall bladder and bile ducts	70	0	70	7
Other abdominal operations	16	1	17	3
Hernia	10	0	10	0
Circulatory system	0	25	25	1
Male genito-urinary system	1	0	1	0
Female genito-urinary system	25	2	27	2
Upper extremities	21	56	77	3
Lower extremities	657	73	730	65
Totals	976	300	1276	102*

*This represents 8 per cent of the total number of operations performed.

[1]Coleman in his recent work finds avertin most toxic to the liver, and in order of decreasing toxicity anesthetics range as follows: nitrous oxide, oxygen and ether vapor, spinal; nitrous oxide and oxygen, local procaine. (Surgery, 1938, 3: 87.)

TABLE II.—COMPARISON OF OPERATIVE AND NON-OPERATIVE TREATMENT OF GANGRENE AND INFECTION 1923–1938

Operation	Gangrene				Infection			
	No. cases	Re-amputation at higher level	Deaths	Mortality per cent	No. cases	Re-amputation at higher level	Deaths	Mortality per cent
Incision and drainage	4	1	1	25	8	0	1	12.5
Amputation of 1 or more toes	28	5	1	3.6	54	3	0	0
Lower leg amputation	2	0	0	0	2	0	0	0
Guillotine amputation	12	6	4	33.3	7	5	1	14.3
Gritti-Stokes amputation	3	0	0	0	1	0	1	100
Thigh amputation	98	0	14	14.3	3	0	0	0
Total operations	147	12	20	13.6	75	8	3	4
No operation	138	..	8	5.8	135	..	4	3

Evipal is excellent for short operations when relaxation is not required, especially in incision and drainage of carbuncles when the electrosurgical knife is used. It must be used with care. The dosage varies greatly. We have seen the maximum dose of 10 cubic centimeters inadequate for the drainage of a septic finger in a young diabetic woman, frail but in good condition; whereas in the next patient, a heavy man of 55, a large carbuncle was incised and drained with 4 cubic centimeters of the solution.

Procaine regionally and locally has little effect on the diabetes, liver, or kidneys, and is used extensively alone or in conjunction with gas anesthesia as mentioned above. It is never used for the amputation of a digit or for incision of a carbuncle.

Spinal procaine is used almost exclusively for operations upon the lower extremities, for most inguinal hernias, and for minor procedures around the rectum and perineum. It is frequently used in operations upon the lower abdomen, especially in women without extensive cardiovascular disease, rarely for operations on the upper abdomen. Fifty to 75 milligrams are adequate for an operation on the lower extremities. The level of the anesthesia rarely reaches above the level of the iliac crest, and, except as noted below, we have never recognized it as directly contributing to a mortality. In many of our patients we doubt that any other anesthetic could have been used with equal safety. We do not believe that relaxation of the sphincter ani secondary to spinal anesthesia is an important cause of gas bacillus infection in an amputation stump.[1]

[1]A total of 1,124 operations have been done on the lower extremities of 805 patients since 1923. The first and only postoperative gas bacillus infection of a stump occurred in 1924.

Avertin we believe to be a dangerous anesthetic in the presence of cardiovascular renal disease, and we never use it in these patients.

PRE-OPERATIVE MEDICATION

Diabetic patients are in general much more susceptible to drugs than are non-diabetic patients of comparable size and age. Moreover, diabetic patients as a group are accustomed to physical and mental insults and are much more tolerant of operations than are most people. In our earlier experiences I was uncertain lest in 2 instances heavy pre-operative medication in preparation for operations had contributed toward fatal outcomes. Our pre-operative medication is therefore simple. One and one-half grains of nembutal, 1½ grains of phenobarbital, or 3 grains of sodium amytal is frequently given to the more apprehensive patients the night before operation. One-eighth to one-fourth grain of morphine sulphate, with one one-hundred-and-fiftieth grain of atropine, is used 30 minutes before an inhalation anesthetic. The older and more debilitated patients are frequently given no preoperative medication. None of our patients operated upon for gangrene are given pre-operative sedation of any kind, and in many instances I have seen these patients sleep through operations.

SPECIFIC OPERATIONS

In Table I are listed the operations performed by my associate, Dr. Theodore C. Pratt, and myself for the 10 year period preceding January 1, 1938. A glance at the table shows that it is not a true cross-section of all the surgical problems these patients present. Operations in the various specialties have not been done by us, and practically all operations upon the thyroid gland in

TABLE III.—OPERATIONS FOR GANGRENE
1923–1938

Operations	No. cases	Deaths	Mortality per cent
Amputation of 1 or more toes	53	4	7.5
Amputation of toe, then major amputation	35	4	11.4
Incision and drainage only	8	0	0
Incision and drainage, then major amputation	2	2	100
Guillotine amputation	33	14	42.4
Lower leg amputation	36	1	2.8
Gritti-Stokes amputation	80	11	13.8
Thigh amputation	266	31	11.7
Toe amputations	88	8	9.1
Major amputations	452	59	13.1

TABLE V.—OPERATIONS FOR INFECTION
1923–1938

Operation	No. cases	Deaths	Mortality per cent
Amputation of 1 or more toes	186	2	1.1
Auputation of toe, then major amputation	18	2	11.1
Incision and drainage only	40	4	10
Incision and drainage, then major amputation	1	0	0
Guillotine amputation	12	5	41.7
Lower leg amputation	10	0	0
Gritti-Stokes	6	1	16.7
Thigh amputation	18	2	11.1
Toe amputations	204	4	2
Major amputations	65	8	12.3

patients with diabetes at the Deaconess Hospital have been done by Dr. F. H. Lahey and his associates.

Major operations include those in which the abdominal or thoracic cavity had been opened, hernias of all types, dissection of the neck, amputation of a digit or extremity, incision and drainage of a carbuncle, open reduction of a fracture, amputation of a breast with or without dissection of the axilla, embolectomy, plastic operations upon the vagina, and ligation of the femoral or popliteal artery.

Minor operations include a variety of lesser procedures such as skin grafts, local excision of superficial benign or malignant lesions, the evulsion of nails, closed reduction of fractures, removal of foreign bodies, drainage of superficial abscesses, high ligation and injection of the saphenous vein. Transfusions and a large number of smaller surgical procedures carried on in the wards are not included. *Multiple operations for the same condition are listed as 1 operation.* Thus a 2 stage resection of the colon or multiple operations upon a lower extremity for a single lesion are listed as 1 operation. As in all our statistics, any patient who, following a surgical operation, dies during that hospital admission is listed as a surgical death regardless of the actual cause of death and regardless of whether or not he has entirely recovered from the condition for which he was operated upon.

TABLE IV.—HEALING IN 100 CONSECUTIVE SUPRACONDYLAR AMPUTATIONS BEGINNING JANUARY, 1935

	Number
Infection of stump	
Major	2
Minor	5
Deaths	
Stump clean	12
Stump infected	2
Mortality—per cent	14

Gangrene of the lower extremities. Of patients who have entered the New England Deaconess Hospital during the past 3 years for treatment of some phase of arterial deficiency, 48 per cent have left the hospital without operation (Table II). The average age of those patients undergoing operation is 65 years. The mortality for all major amputations upon patients with gangrene from 1923 to 1938 has been 13.1 per cent (Table III). Ninety per cent of these patients who have come to operation have had a major amputation.

The many factors entering into the selection of the level at which amputation should be done cannot be repeated here. If, however, one gives careful consideration to the various problems involved, the selection of the level of amputation is not difficult. It is our belief that *guillotine amputation*, preferably through the upper third of the lower leg, is indicated (1) for extensive infection in the presence of severe diabetes; (2) in patients with septicemia secondary to gangrene and infection of the limb; and (3) in debilitated patients whose general condition is so poor that primary healing is not anticipated. *Amputation of a toe* is dangerous in the presence of unlocalized infection and will rarely if ever be successful if pain is severe. It should only rarely be attempted in a pulseless foot if infection has involved the deeper structures of the foot. *Amputation of the lower leg* should never be considered in any patient whose general condition precludes the use of an artificial limb. It should never be done in the absence of pulsation in the popliteal artery, and it should

TABLE VI.—OPERATIONS FOR APPENDICITIS JANUARY, 1924 TO JUNE, 1938

Operation	Without drainage		With drainage		Total cases	Total deaths	Mortality per cent
	Cases	Deaths	Cases	Deaths			
Appendectomy	37	0	6	1	43	1	2.3
Drainage of abscess with or without spreading peritonitis	0	0	6	2	6	2	33.3
Totals	37	0	12	3	49	3	6.1

never be done in the presence of a lymphangitis above the level of the ankle. We have elected amputation through the lower leg in only 7 per cent of our patients with gangrene. *Gritti-Stokes amputation* gives an excellent end-bearing stump, but we are now convinced that in the patient with diabetes it should be used only in selected cases and then only when the surgeon has had considerable experience with the operation. A *supracondylar amputation*, using a circular incision without a tourniquet and with careful closure of the wound without drainage, is the safest amputation we know. In 100 consecutive amputations of this type done at the New England Deaconess Hospital, the mortality has been 14 per cent (Table IV). First intention[1] healing has occurred in 93 per cent of the cases, and in only 2 cases was there deep infection of the stump. We have not used the operation of Callander because of the universal satisfaction from the simpler supracondylar amputations mentioned above.

Infection of the lower extremities. Probably the most important lesions we see involving the lower extremities are those in the feet of diabetic patients with adequate circulation as evidenced by (1) good pulsation in the dorsalis pedis artery, or (2) no primary pulsation but excellent collateral circulation as evidenced by a foot of normal appearance, warm and well nourished. Gangrene may be present but is secondary to infection and local thrombosis, rather than due to a primary arterial occlusion. It is of interest that in this group of patients a marked degree of hypesthesia, at times actual anesthesia, is frequently noted. Only recently we removed the great toe of such a patient in the ward without anesthesia because of the extensive infection which was present, and we have frequently incised and drained infections of the feet in this group of people without anesthesia of any kind. It is in this group of cases that osteomyelitis of a phalanx is so common. Amputation of a digit for osteomyelitis of an interphalangeal joint on a foot with good pulsation in the dorsalis pedis artery is one of the safest and most satisfactory procedures we know (Table V).

We have successfully removed one or more toes in 186 patients, with a mortality of 1.1 per cent. In 18 instances a higher amputation was necessary, and in these unsuccessful cases the infection had already extended to the deeper structures of the foot. It is also of importance that in this group of cases, removal of one toe, particularly the great toe, is frequently followed by the development of a callus and then ulceration in the tip of the adjacent toe (Fig. 1). It is in cases of this type that amputation of all the remaining toes for prophylactic reasons may be indicated (Fig. 2). Amputation through the lower leg is not infrequently advised in this group of patients in preference to long continued and extensive infection involving the deeper structures of the foot.

Amputation of a digit for osteomyelitis of an interphalangeal joint is done with a racquet incision through the proximal phalanx. In cases in which the infection has involved the deeper

[1]Stump completely healed and sutures out in 12 days.

TABLE VII.—FATAL CASES AFTER OPERATION UPON THE GALL BLADDER

Case no.	Sex	Age	Diagnosis	Anesthesia	Operation	Cause of death
3469	M	55	Chronic cholecystitis; cholelithiasis	Gas ether	Cholecystectomy	Streptococcus cellulitis of abdominal wall
3490	F	65	Cholecystitis with abscess and duodenal fistula	Spinal novocain	Cholecystostomy; closure of duodenal sinus	Duodenal fistula; bronchopneumonia
3080	F	53	Hydrops of gall bladder	Spinal novocain	Cholecystectomy	?Cerebral hemorrhage
1999	M	55	Empyema with gangrene and subacute perforation	Novocain and nitrous oxide oxygen	Partial removal of gall bladder	Peritonitis

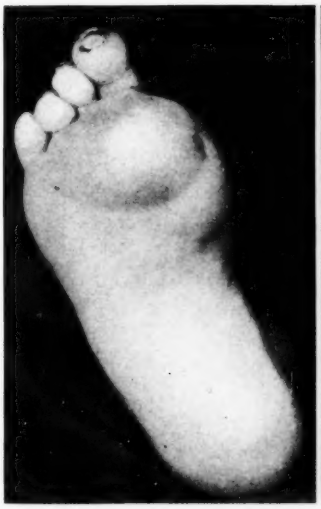


Fig. 1, at left. Ulceration at the tip of the second toe from pressure following amputation of the great toe.
Fig. 2. Same as Figure 1, after amputation of remaining toes.

structures of the foot, the position and character of the incisions used for drainage are of extreme importance (Figs. 3, 4, 5). In most instances adequate drainage will require the removal of one or more toes. In general, incisions should be made too long rather than too short. They should be so placed that, with the foot in the normal resting position, the lower part of the incision will represent the most dependent part of the wound. If infection involves a metatarsophalangeal joint, all of the head of the involved metatarsal should be removed (Fig. 6). For drainage of the great toe, fourth, or fifth toes, lateral incisions are used, and in the case of the fourth toe the head of the fifth as well as of the fourth toe must be removed so that the wound is one wide, open cavity (Fig. 6).

For removal of the middle toe and at times the second toe, a wedge is removed with the incision on the plantar surface of the foot being extended sufficiently to give adequate dependent drainage (Fig. 7). Whenever the head of a metatarsal is excised, all sesamoid bones or cartilaginous tissue should be removed.

We do not use any complicated treatment of the cut plantar tendon. A clean, sharp knife is used. Great care is taken not to pull on the tendon and let it snap back into its sheath. Rather the tendon is cut so as to allow a few millimeters of tissue to project beyond the cut end of the sheath. In an open, infected wound a piece of dry gauze is immediately placed over the cut tendon. A second small piece of dry gauze is then packed loosely over this. After 24 hours the packing is moistened with Dakin's solution morning and evening and is removed in 3 or 4 days. Thereafter the packs are changed daily and are kept moist with Dakin's solution. In larger wounds one or more Dakin's tubes are inserted and 5 cubic centimeters of solution instilled in each tube every 2 hours. In clean wounds to be closed, the tendon is cut with a clean, sharp knife. No other method of treatment is needed.

Infections of the hand. In the splendid symposium on diabetic surgery before the forty-fifth Congres français de Chirurgie, Jeanneney (5) gave an excellent résumé of the difficulty experienced in controlling these infections and offered definite suggestions as to their management. Bothe refers to the large amount of necrosis and the difficulty in controlling palmar abscesses. There is otherwise very little mention of this serious and important problem in the literature. Dr. Walter Garrey and myself carefully studied the 70 patients admitted to the New England Deaconess and Massachusetts General Hospitals between January 1, 1933, and January 1, 1937. Seven and one-tenth per cent of these patients died, and another 7 per cent survived an amputation through or above the forearm. Thirty per

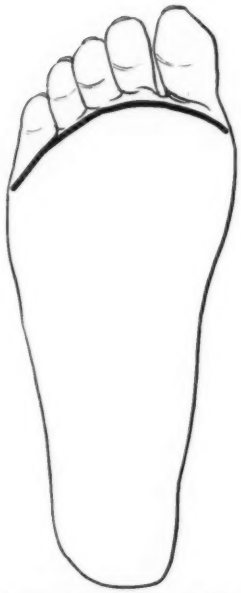


Fig. 3. Incision used for drainage of infection involving the subcutaneous tissues at the base of the toes. This may be combined with removal of one or more toes, or connected with drainage on the dorsum of the foot if necessary.

cent of these patients lost all or a part of one or more fingers. Certain facts seemed to contribute toward these poor results: (1) late hospitalization and inadequate incisions, usually after ambulatory treatment in spite of the known difficulty in controlling infection in patients with diabetes through small inadequate incisions; and (2) the presence of a mixed infection as noted in most cases when finally hospitalized.

Our experience in the management of these cases, particularly of the tendon sheath infections, is too limited to warrant any dogmatic statements at this time. We believe we are justified, however, in advocating that any patient who is seen with an infection of the hand and diabetes should be immediately hospitalized; that operation, if indicated, should be in a bloodless field, and painstakingly done under general anesthesia; and that incisions should be adequate so that the infected area is completely opened. For the simpler paronychia we advocate early removal of the entire nail. For felons we advocate the complete fish-mouth incision, and for infections of the tendon sheath we suggest that the sheath be completely opened throughout its entire length. In case of extension to the radial or ulnar bursæ or

TABLE VIII.—OPERATIONS UPON THE BILIARY TRACT

January, 1924 to June, 1938

Operation	Cases	Stones	Deaths	Mortality per cent
Cholecystectomy	39	33	3	7.7
Cholecystostomy	9	9	1	11.1
Cholecystectomy and choledochostomy	10	9*	0	0
Choledochostomy	2	2	0	0
	60	5	4	6.7
Cholecystgastrostomy (for carcinoma of pancreas)	8		1	12.5
Choledochoduodenostomy (for carcinoma of pancreas)	2		0	0
Totals	70		5	7.1

*In 7 cases stones were present in the duct.

both we believe that the crucial ligament should be divided. If there is beginning necrosis of the tendon at the time of operation, it is our present belief that the tendon can best be removed at the primary operation. Early amputation of a finger for involvement of the bone or joint may greatly shorten the convalescence, but we believe that amputation of the hand should be undertaken only as a life-saving procedure, or when destruction beyond hope of usefulness has taken place, and this latter is rare indeed. In our own experience there is no group of patients in which the judgment and experience of the surgeon will be so thoroughly tried as in the management of a dia-

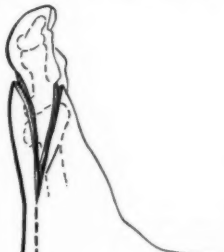


Fig. 4. Incision for amputation of the great toe proximal to the head of the first metatarsophalangeal joint, showing the line of extension of the incision to drain the subfascial area of the medial half of the foot. A similar type of incision is used for the fifth toe.

TABLE IX.—MAJOR OPERATIONS UPON THE GASTRO-INTESTINAL TRACT

January, 1928 to June, 1938

Operation	No. cases	Deaths	Mortality per cent
Stomach and duodenum			
Resection of gastrojejunocolic fistula	1	0	0
Closure of perforation	1	1	100
Judd pyloroplasty	2	1	50
Gastrojejunostomy	1	0	0
Gastrostomy	1	0	0
Exploration—biopsy	2	0	0
Small intestine			
Resection and anastomosis	1	0	0
Entero-enterostomy	1	0	0
Lysis of adhesions for acute obstruction	2	0	0
Colon			
Resection with anastomosis	10	2	20
Excision with colostomy	3	1	33.3
Entero-enterostomy	2	1	50
Closure of perforation	1	0	0
Drainage of diverticulitis	2	1	50
Closure of sigmoidovesicle fistula	1	0	0
Closure of colostomy	1	0	0
Colostomy	1	0	0
Rectum			
Combined abdominoperineal, 1 stage	1	1	100
Combined abdominoperineal, 2 stages	1	0	0
Colostomy and posterior excision	3	1	33.3
Colostomy	4	2	50
Totals	42	11	26.2

betic patient with a spreading infection involving the deeper structures of the hand.

Carbuncles. It is our belief that carbuncles are surgical infections and as such are best treated by adequate incision at the proper time. Four, or 5.6 per cent, of the 71 patients we have operated upon for this infection in the 10 year period have died. All deaths have been in patients with large lesions, 10 centimeters or more in diameter. Careful treatment of the patient's general condition and his diabetes, local heat and x-ray to hasten localization, then crucial incision with undermining of the flaps, using the electrosurgical knife is, we believe, the procedure of choice. The wound is packed with dry gauze. This packing is removed as it loosens, usually in 3 or 4 days. Thereafter the wound is repacked loosely each day with gauze saturated with Dakin's solution or azochloramid.[1]

[1]Azochloramid, 1:3300 in normal saline solution is used 3 times daily, or the oily solution 1:500 in triacetin is used once daily.

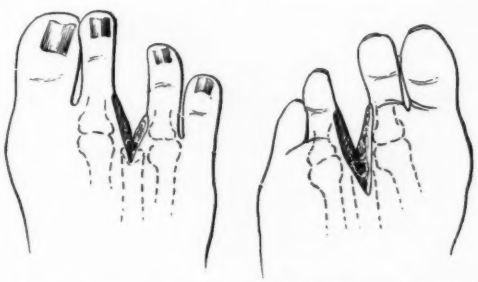


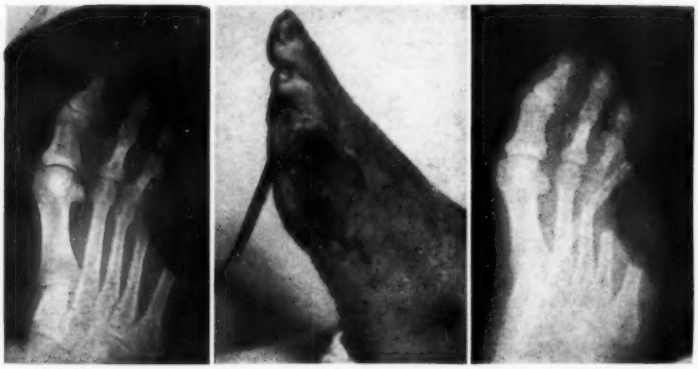
Fig. 5. Incision used for removal of the second or third toe proximal to the head of the metatarsophalangeal joint.

Protection of the surrounding skin is important. It is washed daily with tincture of green soap and water, wiped off with alcohol, and painted with compound tincture of benzoin. Even with this precaution small pustules may develop. Necrotic tissue is removed as it separates, but great care is taken not to subject the patient to the painful removal of tissue before separation is complete. The large carbuncle always begins as a small one, and early adequate treatment should prevent the development of a fatal lesion.

ABDOMINAL SURGERY

Abdominal symptoms due to acidosis. Most of the more recent articles on diabetic surgery give ample space to the syndrome of pain, vomiting, spasm, fever, and leucocytosis, not infrequently associated with acidosis and without any demonstrable organic lesion within the abdomen. We have seen a white count in such a condition as high as 80,000. The mere fact that a diagnosis of perforated ulcer, perforated appendix, or acute pancreatitis is frequently made is evidence that the pain may be severe and the findings diffuse rather than localized. Accurate differentiation can usually be made by a careful history obtained from a member of the family or the patient, and by the generalization rather than the localization of findings. In most instances the diagnosis can be confirmed following a few hours of insulin treatment, since the pain and abdominal signs clear very quickly in the absence of a surgical lesion and usually become more definite in its presence. Although the occasion has never presented itself, we would have no hesitancy in making a small incision under novocain anesthesia did we feel that the findings were such as to make delay unsafe.

Appendicitis. With an increasing number of children maturing and entering adult life, there will be an increasing number of cases of appendi-



a b c

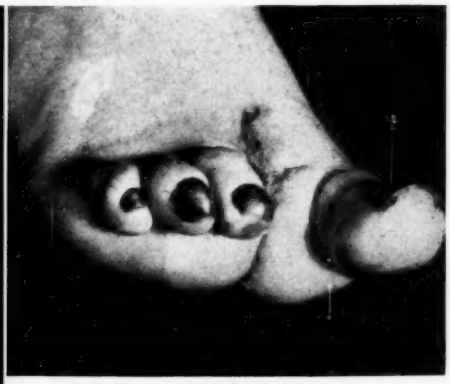
Fig. 6. a, Roentgenogram showing a portion of the head of the fourth metatarsal inadvertently left following amputation of the fourth and fifth toes for osteomyelitis, at another hospital; b, wound through which the head of the fourth metatarsal was completely removed and the fifth metatarsal shortened; c, roentgenogram following second operation, showing satisfactory treatment of the metatarsals.

citis among patients with diabetes. Moreover, the diagnosis of appendicitis in these children is somewhat more difficult to make than in a non-diabetic patient, and failure to recognize the presence of the disease may result more seriously. It is, therefore, a problem of increasing importance, particularly since it would seem reasonable to suppose that an inflamed appendix, which in a non-diabetic child might well subside, might in a diabetic patient progress to perforation and peritonitis. We have seen a number of diabetic children entering the hospital for attacks of abdominal pain in which we were unable to make a diagnosis of appendicitis, and at the same time the pain and symptoms were not associated with acidosis or with any evidence of urinary tract infection. We have operated upon at least 3 of these patients who have had previous attacks which we have seen them through and in whom we were unable to make a diagnosis, primarily because of the absence of demonstrable localized tenderness. We deliberately operated upon each of these 3 children after the acute symptoms had subsided but before any inflammatory process of the appendix would have had time to disappear completely. In none of these 3 children did we find any evidence of pathology in the appendix, the regional glands, or the lower 3 feet of ileum. We, nevertheless, feel that it is safer to remove a normal appendix in a diabetic child having recurring attacks of pain not otherwise explained than it is to run the risk of overlooking a mild appendicitis which at a later date and under less favorable circumstances may become acute and progressive. In the child with diabetes, which is controlled and has been controlled, it would seem as though operation under proper conditions could be done with a mortality little if any higher than that in a non-diabetic patient (Table VI). Early hospitalization and early operation for signs and symptoms suggestive of appendicitis is, we believe, even more clearly indicated in the patient with diabetes than in the patient without it.

Operations upon the biliary tract. We do not believe in operation upon the so called stoneless gall bladder with indefinite digestive symptoms. We do advise operation upon a diabetic patient with digestive symptoms referable to gall stones demonstrated by x-ray, or because of recurrent attacks of pain characteristic of or consistent with that due to gall stones when associated with roentgenological evidence of cholecystic disease. We believe that the finding of stones, even in the presence of very few symptoms, is an indication for operation in a diabetic patient in otherwise good condition.

We believe that the risk of biliary tract disease as well as of biliary tract surgery is greater in the diabetic than in the non-diabetic patient. Some of the patients operated upon in this group were extremely poor risks, in which a mortality even in a non-diabetic patient might have been accepted as a definite possibility. On the other hand, a study of the fatal cases shows at least 2 instances in which a fatal outcome was not anticipated and in our judgment should not have occurred (Table VII). Case No. 3469, after an operation of election on a man of 55, died of a streptococcus

a



b

Fig. 7. a, Plantar and, b, dorsal views of incision following amputation of the second toe through the metatarsal for infection involving the metatarsophalangeal joint. The incision has been extended on the plantar aspect because of infection involving the deeper structures of the foot. The patient, a 72 year old diabetic woman, was discharged from the hospital with the foot completely healed 67 days after operation.

cellulitis of the abdominal wall, and Case No. 3080, a woman of 53 supposedly in good condition for a diabetic of her age, died in a coma not of diabetic origin and not too satisfactorily explained; a third patient recently operated upon also had an unlooked for reaction, characterized by a semi-conscious state and other symptoms at first thought to be due possibly to cerebral hemorrhage; but this patient, after a somewhat delayed convalescence, recovered satisfactorily with no evidence of a cerebral accident. It is these experiences which make me feel that I cannot operate upon the diabetic patient with gall stones without accepting a slightly higher mortality than in non-diabetic patients of comparable age and with comparable pathology (Table VIII). It is also these experiences which make me feel that the indications for operation in this group should be clear-cut.

Our experience with acute cholecystitis in patients with diabetes is limited. This experience suggests, however, that the so called acute gall bladder in a patient with diabetes will not subside with the same frequency that it will in the non-diabetic patient. We have seen 5 such patients and in only 1 instance did the acute process subside so that a procedure of election could be done. Others progressed and operation had to be undertaken during the presence of an acute inflammatory process. It is now our feeling that if a patient is admitted with an acute cholecystitis, we should probably be inclined toward operation as soon as the diabetic state is under reasonable control.

During the past 10 years we have done 10 anastomoses between the stomach or duodenum and the biliary system (Table VIII). It is our impression that this procedure can be carried out with a mortality not materially greater than that in non-diabetic patients. Almost without exception these operations are done under novocain anesthesia. A minimum of exploration is done and the gall bladder or, in its absence, the common duct is anastomosed to the stomach or duodenum. A simple type of anastomosis such as is commonly used in gastro-intestinal work has proved adequate. In none of these cases has there been leakage, and we see no indication for the use of a foreign body such as a button or rubber tube.

Operations on the gastro-intestinal tract. That extensive operations on the gastro-intestinal tract may be carried out in patients with long-standing diabetes was well shown by a recent patient seen and operated upon by us at the request of Dr. Joslin.

CASE No. 5963. A man of 57 with a diabetes of 15 years' duration entered the George F. Baker Clinic on March 20,

1938, because of abdominal pain, diarrhea, and loss of weight and strength. He had had a posterior gastroenterostomy for duodenal ulcer performed 19 years before. His surgical convalescence at that time was not a smooth one, nor had he ever been completely relieved of his symptoms. In recent years he had had several severe hemorrhages, and about 2 years before we saw him a diagnosis of gastrojejunocolic fistula had been made. In spite of this condition he had remissions when he was reasonably comfortable and was able to carry on with his work as a wool broker. Bowel movements in the hospital numbered from 10 to 15 in 24 hours, sometimes more, and followed immediately the ingestion of food or fluid by mouth. Palliative treatment was wholly unsuccessful. On April 6th, 2 weeks after he was first seen, a jejunostomy for feeding purposes was done. In spite of intensive efforts to improve his nutrition, 2 weeks later his blood serum protein had diminished further from 5.3 per cent to 3.5 per cent, and the diarrhea persisted just as though food were taken by mouth. On April 20th, 1 month after he was first seen and 2 weeks after his jejunostomy, laparotomy was performed. A closed type of operation was carried out. The transverse colon, jejunum, and lower two-thirds of the stomach were removed between clamps. A Kerr end-to-end anastomosis was done on the transverse colon and on the jejunum, and fortunately the third portion of the duodenum was so placed that it was readily anastomosed to the open end of the stomach. A cecostomy was then done. The patient made an uneventful postoperative convalescence, except that 19 days after operation he had a sudden massive hemorrhage in the middle of the night and 4 days later a second hemorrhage, though not so large, requiring in all 3 transfusions. From then on there were no further complications and he left the hospital on June 6th, 2½ months after admission, symptom-free and in excellent condition.

Examination of the specimen showed the "stomach connected with the jejunum by an opening 2.5 centimeters in diameter, the edges of which were smooth; the jejunum was connected with the colon by 3 openings, the largest 3 centimeters in diameter, each of the other 2 measuring 1 centimeter in diameter." In addition to these openings there was a jejunal ulcer 1.2 centimeters in diameter.

The number of operations which we have performed on the gastro-intestinal tract is not large, as shown in the accompanying table (Table IX). It is our belief, however, from this small experience and from a larger experience with gastro-intestinal surgery in non-diabetics and in diabetic patients with other lesions that: (1) whenever possible every resection of the large bowel should be a 2 stage procedure, regardless of the apparent condition of patient; (2) a preliminary transverse colostomy is preferable to cecostomy preceding resection and anastomosis in patients with an obstructing lesion of the left colon, provided the patient is having obstructive symptoms and a cleansing of the bowel above the obstruction is found to be impossible; in all other instances a preliminary cecostomy should be undertaken; and (3) because of the relationship between infection and diabetes, great care should be taken in the selection and execution of the surgical procedure so as to assure a minimum of local soiling.

SUMMARY

One thousand, two hundred and seventy-six operations upon patients with diabetes mellitus are reported. The case mortality is 8 per cent.

The importance of considering the effect of the diabetes upon the patient's cardiovascular renal system is stressed.

Five hundred and thirteen operations for gangrene are reported with a mortality of 13.1 per cent. The mortality for major amputations is 13.1 per cent. A primary supracondylar amputation was done in 51.8 per cent of the cases. In 100 consecutive supracondylar amputations for gangrene 93 per cent healed by first intention; in only 2 of the infected cases did the infection involve the fascia.

Two hundred and four patients with good local circulation have had amputations of 1 or more toes for osteomyelitis or recurrent ulceration. There were 4 deaths, a mortality of 2 per cent. In 18 cases a higher amputation was necessary; in 184, or 90 per cent, of these patients complete healing occurred.

Important technical considerations for the drainage of infected feet are given. The importance of early hospitalization and adequate surgical treatment of infections of the hand is stressed, and the results in 70 such cases are summarized.

Carbuncles are considered as surgical lesions. Electrosurgical drainage after adequate local and general preparation is advocated. Results after operations for appendicitis and cholelithiasis are given; and a successful resection of the jejunum, transverse colon, and stomach for gastrojejunocolic fistula is reported.

BIBLIOGRAPHY

1. Bothe, F. A. Surgery in diabetes. Pennsylvania M. J., 1934, 37: 661.
2. Callander, C. L. A new amputation in the lower third of the thigh. J. Am. M. Ass., 1935, 105: 1746.
3. Coleman, F. P. The effect of anesthesia on hepatic function. Surgery, 1938, 3: 87.
4. Fredet, P., and Jeanneney, G. La Chirurgie chez les Diabetiques. Paris: Rapport, Ass. franç de chir., 45th Congrès français de chirurgie, 1936.

FACTORS DETERMINING SELECTION AND ADMINISTRATION OF ANESTHETICS

WESLEY BOURNE, M.D., F.R.C.P., Montreal, Canada

IN ANESTHESIA it is axiomatic that the drugs employed be chosen to suit the general condition as well as the surgical requirements of a given individual. This is equally true concerning the methods of their administration. Both become extremely important if the patient suffers some definite additional disability. It is well known that anesthetics are apt to disturb metabolism and to depress function. If these are already interfered with, the selection of the materials used and the modes by which they are given must be considered with the greatest care. While the desired and beneficial actions of anesthetics cannot be forgotten, the harmful effects may turn out to be manifold, indeed, all too often multiform, like *the wretchedness of earth.* Let us review a few of these ill-effects, those on the blood, the liver, and the kidneys; and let us remember, at this time, that the disturbances which take place in these parts do so concurrently and in an interdependent manner with the many other upsets in the rest of the organism. These disturbances are as various as the hues of the rainbow; as distinct, too, yet they are as intimately blended.

EFFECTS OF ANESTHETICS

In the blood. Of the many changes which anesthetics may produce in the blood, I shall confine my remarks to the two which seem more closely related to the subject under consideration, namely, blood concentration and acidosis. Barbour and I (1, 2, 3) have shown that ether anesthesia causes the blood solids to increase by 2 to 3½ per cent of the total weight of the blood. This enormous blood concentration was found to be due chiefly to the migration of water from the blood to the tissues, considerable increase in the water content of the muscles having been shown following the anesthesias of the more powerful drugs, chloroform and ether. This blood concentration effect can be lessened markedly by the copious use of water or dilute solutions before, during, or after narcosis.

This brings us to that very grave feature of dehydration so often seen in the handicapped patient, and to an important point in the selection of anesthetics. Intravenous injections of blood and isotonic solutions should be made prior to anesthesia, and the less toxic substances, nitrous oxide and cyclopropane chosen for administration; or, at least in some instances, it may be more propitious to resort to some form of regional anesthesia. More attention, than is generally customary, ought to be paid to the dehydrated patient who is about to be operated upon.

That acidosis is very liable to occur as a result of anesthesia has been abundantly proved, and Roscher has shown that it may take place even after local or spinal anesthesia. Stehle and I (4, 25) have demonstrated that phosphoric acid leaves the muscles during ether anesthesia and is neutralized by the bases, sodium and potassium. The phosphates are stored to some extent in the liver and, after recovery, when kidney function is resumed, they are then redistributed and partly excreted. Ronzoni, Koechig, and Eaton have given evidence that the lactic acid of the blood is increased, which harmonizes with the idea that phosphates and carbohydrates are intimately associated in metabolism, there being a common precursor, a hexose phosphate, called by Embden *lactacidogen.* Just recently, Pratt has shown that there is considerable variation in the effects of anesthetics on the blood-sugar level, and that even cyclopropane is capable of raising the blood-sugar. He states, "There is little evidence to suggest that the rise of blood-sugar is other than a welcome physiological compensatory phenomenon." Be this as it may, acidosis becomes a serious matter for the handicapped patient, especially he who comes to operation already in a condition of acidosis, as for example, the child with severe vomiting or the diabetic. It is our bounden duty, therefore, carefully to select those anesthetic agents and methods of administration which are least likely to produce or to enhance the acidotic state.

The choice lies between cyclopropane with nitrous oxide as a diluent, and spinal or local anesthesia. Of this latter, I shall have more to say later on. Of the former, it is timely to point out that the superfluity of oxygen, which is always given with cyclopropane, will very considerably lessen and prevent what little acidosis this gas

Presented in the Symposium on Surgical Procedures on the Handicapped Patient, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

may perchance produce. With the proper alkaline state of the blood in view, whenever it is possible, the glycogen reserves of the body should be supported well before operation and after complete recovery from anesthesia. I dislike using glucose during operation because at this time there is apt to be hyperglycemia. It has long been my practice to administer a specially balanced hypotonic alkaline sodium and potassium phosphate solution immediately after operation, having demonstrated that nausea is markedly reduced and that this solution tends to stimulate the depressed individual (5). One pint of solution to every 50 pounds of body weight is given rectally. This bulky, watery, and alkaline solution not only reduces the acidosis but lessens the blood concentration and hastens recovery. This solution contains potassium ions which have been shown by Nothmann and Wagner, and Nothmann and Guttmann to be the most stimulating to any depressed, living thing, especially when the phosphate anion is present and when the medium is alkaline. Thus, in particular, the handicapped patient is led more readily to a salubrious state. Needless to say fluids are not to be given to the patient with edema such as that from cardiorenal insufficiency.

So much then, from a pharmacological point of view, for a consideration of some of the ill-effects which anesthetics may produce on the blood. So much, too, in consequence, concerning the choice of the drugs and the conduct of narcosis.

On the liver. The liver, with its immensity, its double blood supply, its 200,000 (Sappey) lobules, possessed of orderly innermost arrangements, its many vital processes, assimilatory and secretory, and its diurnal rhythmic activity, is truly a prodigious organ, the greatest in the body. Notwithstanding the redundancy of this huge structure it is very vulnerable and its cells are extremely susceptible to insult, so that in the very performance of their functions these cells succumb all too easily. Yet they are endowed with remarkable regenerative powers, as has been shown separately by several sets of careful observers, and reviewed extensively elsewhere (6). Suffice it to say now that Mann and Magath have demonstrated that it is possible to remove all but the two lower right lobes of the dog's liver, or approximately 70 per cent, without serious damage to the portal and vena cava circulation. The animals do not seem to suffer from such loss. The reason for this may readily be ascertained by examination a few months after operation, when the two remaining lobes will be enlarged and the amount of tissue practically the same as before operation. However, despite liver regeneration, despite the normal appearance of the tissue under the microscope, it has been conclusively proved, since the introduction of dye tests, that complete functional recovery is not fully established for some considerable time later, at least following the administration of certain poisons like phosphorus or chloroform. In other words, such a physiological test is more sensitive than any estimate based on histological evidence.

More recently, Rosenthal and I (23) studied the effects of various anesthetics on the liver, as indicated by bile-pigment disturbances and by the bromsulphalein dye test for hepatic function. One result of our study was the conviction that the dye test affords a much more definite index of injury to the liver cells than do estimations of bile pigments in the blood and urine. Even after 15 minutes of chloroform inhalation healthy dogs always show considerable impairment of liver function; indeed, the damage is frequently so severe that recovery is not effected for 8 or 9 days. Two hours of chloroform anesthesia requires all of 6 weeks for return to normal. When ether is used similarly, the functions of the liver are definitely affected and proportionately to the degree and length of narcosis; but they return to normal in about 48 hours, even after a 2 hour period of anesthesia.

Our experiments with nitrous oxide, as well as with ethylene, showed that when sufficient oxygen is supplied, anesthesia from 1 to 2 hours produced neither immediate nor delayed impairment of hepatic function; whereas when the percentages of oxygen were purposely reduced, all the animals sustained an immediate impairment of function, which did not return to normal as with ether, but required about 6 days for recovery. This is an important lesson to learn, namely most carefully to avoid anoxemia during anesthesia.

Still more recently, as investigations have revealed, that is, at least from a practical point of view, liver function is not disordered following the anesthesias produced by the derivatives of barbituric acid (7), by avertin (8, 11), by vinyl ether (9), and absolutely not at all, by cyclopropane (20). In each of these instances the basic work was done on dogs, and with each drug verification was obtained from observations made on man. It may be pointed out at this juncture that in so far as we are presently concerned, the physiology of the dog's liver is identical with that of man's, except that the dog's is somewhat more resistant to poisons; and most cogently, the dog's dose of each of these substances is much greater than that of man's, for example, in the case of avertin, it is 5 times larger. With these apposite, but cursory, considerations of the rôle of the liver in metab-

olism and of the effects of anesthetics on hepatic function, it is easy to see the importance of careful selection and administration of anesthetics in surgical procedures on the patient who suffers from liver disorders. Here again both methods and materials must be suited to the general condition as well as the special surgical requirements of a given individual. So much for some of the manifold amazements to be met in one organ.

In the kidney. As changes, analogous to those which anesthetics produce in the liver, undoubtedly occur simultaneously in other organs, those which may take place in the kidney will be dealt with peremptorily. It has been known for a long time that anesthesia, generally, diminishes the volume of urine secreted, and data exist concerning the effect of anesthetics on metabolism as represented by the composition of the urine. In 1928, Stehle and I (26), by using dogs with fistulas in the bladder, showed that in ether anesthesia there is either a complete cessation in the formation of urine or a decided oliguria; that if the urea and the chloride concentrations are low in the control period, they may rise under ether anesthesia; but, when the initial concentrations are high, anesthesia causes a fall in the amounts and concentrations of the urea and chloride concentrations of the urine; and that a secretory mechanism is involved in contradistinction to the filtration-re-absorption theory regarding the secretion of urine. The previously mentioned blood concentration (1) found in ether anesthesia may now be seen to be closely associated with this diminished efficiency of the secretory process. Bruger, Dreyer and I (11) have made observations with avertin on dogs with bladder fistulas, and on man. We found that in the former anuria always occurred immediately after administration and lasted for a period varying between 15 minutes and 1 hour, after which marked oliguria supervened; whereas with the human cases, who received only one-fifth of the dose given to dogs, anuria did not take place, but there was pronounced oliguria. Nevertheless, throughout the periods of oliguria for both dog and man the percentage excretions of urea were always increased, which indicates that there is no evidence of severe kidney depression. During the postanesthetic period there is invariably an enormous excretion of phosphoric acid which is undoubtedly involved in the acidosis which was found to be present, and similar to that produced by ether. It has been shown by Waters and Schmidt that the urinary output is usually suppressed during cyclopropane anesthesia and a compensatory increase in excretion occurs several hours following anesthesia.

In fine, it may be said that all general anesthetics cause some depression of kidney activity, wherein the rate of secretion and composition of the urine is lowered. The degree of depression varies directly with the depth of narcosis and the effects are influenced by the condition of the kidneys, by the water content of the blood, and by the duration of anesthesia. With these factors in mind, it is evident that in surgical procedures on a patient handicapped by kidney disease, both the selection and the administration of anesthetics become matter and actuality of grave consequence.

CHOICE OF ANESTHESIA

Although it has been done rather discursively, yet I have attempted to show the close interrelationship of these 3 sets of ill-effects which occur in anesthesia, that is, upon the blood, the liver, and the kidney. So close is the connection that broadly they may be regarded as good examples of the disturbance which anesthetics produce on metabolism as a whole. This interpenetration of ill-effects simulates the great interlocking of the normal vital functions. It is timely, therefore, to consider more specifically a few of the salient features concerning the choice of anesthetics and the conduct of narcosis.

At once, that real emotion, fear, presents itself. In this most strenuous of Iron Ages, not nearly enough is being done adequately to assuage the throes of fear. We should cultivate the psychological approach rather than pooh-pooh it. We should win the patient's reliance by reassurances through soft voice and gentle gesture. Not until full confidence is gained will sedative drugs give their most favorable results. I believe that such drugs should be given more freely than is customary, but in smallish, repeated doses (especially for the aged or handicapped patient), begun sufficiently ahead of the time of operation in order that enough may be administered to almost completely obtund the activities of the cerebral cortex. Of the lot, it would seem that the combination of morphine and scopolamine is generally most desirable, and Waters (28), of the University of Wisconsin, who has been making observations with increased doses, finds "little if any change in oxygen consumption, a decreased minute volume with morphine alone, a slight increase with scopolamine alone, and a distinctly less reduction in the minute volume with the combination." These findings constitute an example of real synergism. Of course, when it is desirable to use avertin, this drug takes the place of morphine, and atropine only may be given with it. The most important reason for increased premedication is the removal

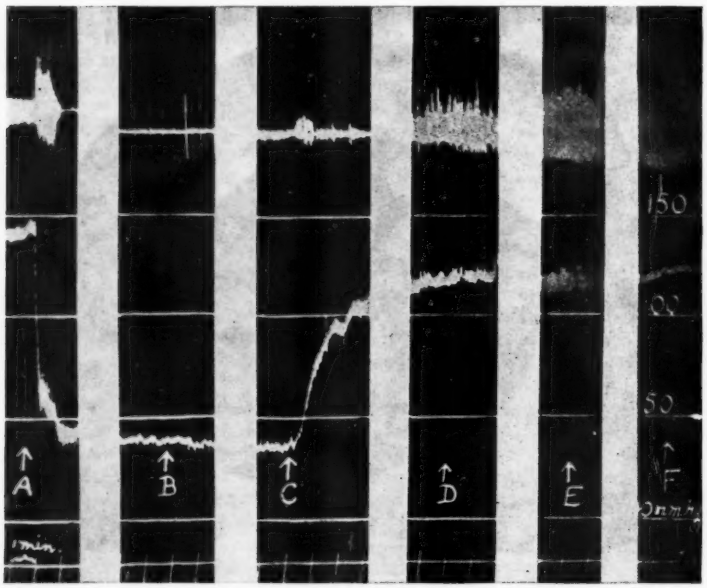


Fig. 1. Respiration and blood pressure tracings; time recorded in minutes; dog, female, 6.4 kilograms; operative procedures under ether anesthesia. A, Injection of histamine (0.5 milligram per kilogram per minute for 16 minutes) was started; B, histamine stopped; C, 10 minutes later, a mixture containing 1 milligram per kilogram of ephedrine sulfate and 0.5 milligram per kilogram of pituitary extract (laboratory preparation) was injected; D, E, and F were 15, 30, and 60 minutes later, respectively; ether was required after E to keep the animal quiet.

of fear. The apprehensive, the frightened individual will all too often become severely shocked, particularly in spinal or other forms of regional anesthesia. If sedation is complete, there will be much less fall in blood pressure than otherwise, little or no nausea, and an agreeable grade of amnesia. With the exception of those who are *in extremis*, I see no contra-indication to the use of sedative drugs in the case of the handicapped patient, all the more as it is recommended that small doses be given and only repeated in accordance with their effects.

Analeptics. At this conjuncture, it may not be amiss to turn our attention to the analeptics. We have so little of exact knowledge about this group of drugs. I shall do no more than draw attention to some more or less recent work on the subject. Melville, of the department of pharmacology of McGill University, has demonstrated that when the pressor principle of posterior pituitary extract is mixed with ephedrine and administered to experimentally shocked dogs, the result is more effective than larger individual quantities of these drugs in restoring blood pressure and respiration and in abolishing general collapse. Histamine causes a precipitous fall in blood pressure with marked slowing and irregularity of respiration so that the dog finally dies. If to such a shocked dog 2 milligrams per kilogram of ephedrine, or 1 milligram per kilogram of pituitary extract, is injected, in either case, there results a temporary rise in blood pressure with some temporary restoration of respiration, but the animal rapidly relapses and dies shortly. If now, as is shown in Figure 1 (by permission of Dr. Melville), a similarly shocked dog is given intravenously a mixture containing 1 milligram per kilogram of ephedrine sulphate and 0.5 milligram per kilogram of pituitary extract, there occurs a sudden marked rise in blood pressure which is well maintained, the respiration becomes also definitely improved, and soon, owing to the apparent recovery of the animal, ether must be again administered. "The effects are presumably not due solely to the circulatory actions of ephedrine and pituitary extract; to arteriolar (ephedrine) and capillary (pituitary) constriction.

Since ephedrine possesses a stimulating action upon the central nervous system in general, as has been shown by various authors and recently studied more specifically by Raginsky and Bourne (21), it seems reasonable to suppose that in conjunction with the prolonged effects upon the heart and circulation, the central nervous system action of ephedrine plays some rôle in the complete restitution of the shocked animal." The united action of these 2 chemical entities constitutes perhaps the best known example of synergism in pharmacology.

Recently, O'Shaughnessy and I, at the Grace Dart Home Hospital for Pulmonary Tuberculosis and at St. Mary's Hospital, Montreal, have had cause to administer these 2 drugs 86 times, during that many spinal anesthesias, 23 in thoracic surgery and 63 for abdominal operations. Figures 2 and 3 are respectively illustrative. It may be stated that "2400" is the same "laboratory preparation"[1] as used by Dr. Melville and was made in the department of pharmacology of McGill University. In the period of time over which this analeptic mixture was given during anesthesia on 86 occasions, there were 199 spinal cases at the two hospitals. The 113 others did not require analeptics during their operation periods, thus, herein is a proof of the firm belief which I have held for some time, namely, that analeptics should not be used routinely nor in anticipation of shock. They tend to stimulate the central nervous system. Raginsky and I (21), have shown that ephedrine reverses the effects of avertin and will undo the desired and purposely produced actions of morphine and scopolamine. What is more, it is known that stimulating drugs may cause contrary results when used in normal beings or prior to an indication. Again, the fact that analeptics were not needed in so many of these cases tends to prove the statements made above in favor of complete sedation, particularly that "there will be much less fall in blood pressure than otherwise."

Figures 2 and 3, with their legends, require little further elucidation. It will be seen in Figure 2 that the mixture of ephedrine and pituitary extract was given twice. This is seldom necessary. Usually, when it is deemed advisable to use these materials, their hypodermic administration will suffice. The intravenous avenue is not recommended unless the patient is very far gone (it was hardly indicated in the case recorded in Figure 2), because, on occasion, when this mixture is placed directly into the blood stream, the blood pressure and pulse rate will rise very alarmingly high.

[1]Of the pituitary extract preparations on the market, that known as pitressin has the greatest amount of pressor principle.

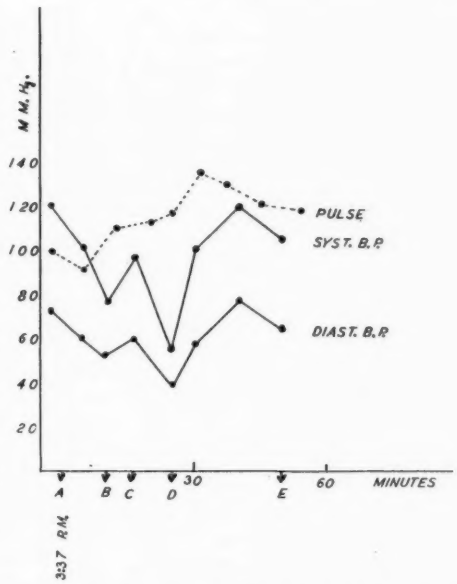


Fig. 2. M. L., a male, 24 years of age, date of operation was January 19, 1938; thoracoplasty performed: first, second, and third ribs, left. At 2.00 p.m. one-fourth grain of morphine and one-hundredth grain of scopolamine were administered; at 3.00 p.m. one-fourth grain of morphine and one-hundredth grain of scopolamine were again administered. In both instances these were injected subcutaneously. A, Spinal injection of 14 cubic centimeters of one-fifteen hundredths of percaine solution; Etherington-Wilson technique; patient sitting up for 55 seconds; B, 5 units of "2400" with three-eighths grain of ephedrine injected hypodermically; C, operation begun; D, 5 units of "2400" with three-eighths grain of ephedrine given intravenously; E, operation finished; one-fifteenth grain of strychnine was administered subcutaneously, and 1000 cubic centimeters of 5 per cent dextrose was given intravenously.

In the case recorded in Figure 3 there was a moderate fall in blood pressure attendant on the intrathecal injection of percaine, a subsequent marked fall during the manipulations of the pylorus, and an excellent recovery following the hypodermic administration of the mixture of ephedrine and pituitary extract. It is pointed out at this time that we should not expect too much from this analeptic mixture. Other well established measures must not be neglected, indeed, the body fluids ought all the more to be sustained. Recently we have been in the habit of giving strychnine, 1/15 of a grain at the end of operation, and 1/30 of a grain every 4 hours after, for 3 more doses. This practice is rather empirical, but it is thought

Fig. 3. G. R., a male, 36 years of age; date of operation was April 20, 1938. A gastro-enterostomy with ligation of pylorus and appendectomy were performed. At 12:30 p.m. a subcutaneous injection of one-fourth grain of morphine and one-hundredth grain of scopolamine was done. This same injection was repeated at 1:40 p.m. A, Spinal injection of 15 cubic centimeters of one-fifteen hundredths percaine solution was given; Etherington-Wilson technique; patient sitting up for 45 seconds; B, operation begun; C, 5 units of "2400" with three-eighths grain of ephedrine administered hypodermically; D, operation finished. One-fifteenth grain of strychnine was given subcutaneously and 1000 cubic centimeters of 5 per cent dextrose was injected intravenously.

that through the action of strychnine on the spinal cord, muscle tone might be improved following spinal anesthesia.

Before we leave the topic of analeptics, a few remarks upon carbon dioxide are relevant. Waters (29), has shown that carbon dioxide may produce convulsions, that surgical shock is not the result of low carbon dioxide in the blood and tissues, that anesthesia does not cause a lowering of the carbon dioxide content of the blood and tissues, that postoperative pulmonary atelectasis is not necessarily prevented by carbon dioxide and oxygen, and that carbon dioxide is a waste product of body metabolism, just as are the constituents of urine. Waters advises never to apply carbon dioxide therapy or rebreathing to prevent or ameliorate shock. Simple oxygen therapy is more satisfactory. During anesthesia, dead space and rebreathing ought to be avoided as much as possible, and the carbon dioxide of the expired air removed by soda-lime. Waters uses carbon dioxide solely as an analeptic when it is desirable to accomplish rapid elimination of toxic volatile gases, and then a small stream of pure carbon dioxide is directed toward the face. These teachings, although directly antithetical to those of Yandell Henderson, seem sound. It may be that untold harm has been done during the widespread employment of carbon dioxide, especially in anesthesia. It may be that the more its value as a drug is magnified, by so much the more will its true physiological significance be forever kept in mind. We must be wary of its use in the case of the handicapped patient.

ANESTHETIC PROCEDURES

Thus far I have repeatedly emphasized the importance of carefully selecting those anesthetic agents and methods of administration that are least likely to supplement any pathological condition which may exist in a patient about to be operated upon. I shall now be more specific, and state positively that in the light of our present knowledge we may make selection from 1 of 3 procedures, namely: regional anesthesia, that is, local or spinal; general anesthesia with the gases, nitrous oxide and cyclopropane; or, a combination of the two. All other forms of anesthesia seem to be contra-indicated in the case of any kind of handicapped patient. In discussing these 3 procedures, I shall consider the anesthetic materials jointly with the means of their administration, and try to show their suitability to the various types of handicapped patients, which, broadly, may be regarded under the themes: anesthesia in brain surgery; anesthesia in cases of toxic goiter; that for thoracic surgery, chiefly pulmonary; for those with cardiovascular disorders, wherein there is myocarditis or failing compensation; those with impairment of liver function; for those suffering from the effects of intestinal obstruction; those with diseased kidneys; and, anesthesia on the occasion when the additional disability is some blood dyscrasia. Properly to investigate such a large question, or set of questions, while it might yield great advantages, is beyond the scope of this paper, yet some relevant inklings will be made.

Regional. Procaine, nupercaine, and pontocaine are the drugs just now in favor for producing regional anesthesia. Virtually, they cause little, if any, impediment in the vital processes. Their employment should, therefore, be encouraged.

But, in execution, local infiltration, field block, and the different forms of nerve block anesthesia are found by a large number of surgeons to be tedious and time consuming. Spinal anesthesia, on the other hand, has become more particularly a part of the duties of the anesthetist and, in consequence, not only is the surgeon freed of the bother of it, but, through increased individual experience, the dangers have become almost negligible. The advantages of spinal anesthesia are very great, especially on account of the muscular relaxation and the excellent recovery. O'Shaughnessy and I (10, 14), have had very satisfactory results with the Etherington-Wilson technique for spinal anesthesia in more than 1200 cases. It would seem that spinal anesthesia is only contraindicated wherein, for one reason or another, the fall in blood pressure, which it frequently causes, is to be feared, as for example, in advanced cardiovascular disease. As mentioned before, it is very strongly recommended that relatively large quantities of depressant drugs be given prior to the production of all forms of regional anesthesia, that is, sufficient to thoroughly subdue the activity of the cerebral cortex and so replace fear by considerable bemusement.

General. Even for the patient who comes to operation without some additional disability, it is becoming more and more universally conceded that even ether anesthesia may be eschewed and place given to less disagreeable and less harmful substances. If this be true, then, how much more so must it be in the case of the handicapped individual. For the production of general anesthesia, I know of no better combination than avertin as a clyster to the patient in bed, about half an hour before the operation time—atropine may be given simultaneously—followed in the operating room by a mixture of cyclopropane, nitrous oxide and oxygen. The main object of the nitrous oxide is that of a diluent. More often than otherwise, it is advantageous to give these gases by the intratracheal method. In all cases of operations about the head, neck and chest (one thinks more particularly of those on the brain and on the thyroid gland) this method precludes respiratory obstruction and obviates interference with the surgical procedure from the anesthetist. This method also gives absolute assurance of a plentiful supply of oxygen directly to the lungs. Oxygen is always beneficial in anesthesia, and especially so in the incidents of blood dyscrasias, cardiac disorders, liver or kidney affections, and disturbances in general metabolism. Again this intratracheal method affords quieter breathing and a softer abdomen even though narcosis is not profound.

Combination of regional with general anesthesia. With respect to a combination of regional and general anesthesia, exigencies may arise in which there exist some good reasons against the use of pre-anesthetic drugs, or, at least, of large doses of them; then, for psychological purposes, the gases may be given together with the production of whatever form of regional anesthesia is chosen. The one supplements and enhances the power of the other; much loss of the gases is required, and, then, too, the patient is all the better for the copious supply of oxygen contingent upon the performance. There are several surgeons and anesthetists who are very much in favor of the combination of these 2 precedures.

SUMMARY

1. Some of the effects of anesthetics on the blood, the liver, and the kidney are reviewed. As their interrelationship is explained, these effects are shown to be good examples of the disturbances which anesthetics produce on metabolism as a whole.

2. The blood concentration, the acidosis, and the impairments of the functions of the liver and kidney as well, which anesthetics may cause, are shown to be alleviated by the rectal administration of large quantities of a hypotonic solution of alkaline sodium and potassium phosphates.

3. In order properly to allay fear, relatively large doses of cerebral depressants are advocated, principally avertin or morphine and scopolamine.

4. It is shown that comparatively large amounts of morphine and scopolamine do no harm.

5. Analeptics are considered, and a mixture (Melville) of ephredrine with the pressor principle of posterior pituitary extract is recommended.

6. Data are presented concerning the clinical use of this mixture in spinal anesthesia.

7. The present liberal use of carbon dioxide is strenuously deprecated and reasons are given (Waters, 29).

8. For the handicapped patient, one of three procedures is recommended, namely, regional anesthesia, particularly spinal; general anesthesia with the gases, nitrous oxide and cyclopropane, especially by the intratracheal method; or, a combination of the two.

BIBLIOGRAPHY

1. Barbour, H. G., and Bourne, W. Heat regulation and water exchange: the influence of ether in dogs. Am. J. Physiol., 1924, 67: 399–410.
2. Bourne, W. Blood concentration and body temperature in anesthesia. Brit. J. Anæs., 1924, 2: 36–39.
3. Idem. The influence of diathermy in anesthesia on body temperature, blood concentration, and acidosis. Brit. J. Anæs., 1926, 4: 87–91.

4. Bourne, W., and Stehle, R. L. The excretion of phosphoric acid during anesthesia. J. Am. M. Ass., 1924, 83: 117–118.
5. Bourne, W. On an attempt to alleviate the acidosis of anesthesia. Proc. Roy. Soc. Med., 1926, 19: 49–51.
6. Idem. Anesthetics and liver function. Am. J. Surg., 1936, 34: 486–495.
7. Bourne, W., Bruger, M., and Dreyer, N. B. The effects of sodium amytal on liver function; the rate of secretion and composition of the urine; the reaction, alkali reserve, and concentration of the blood; and the body temperature. Surg., Gynec. & Obst., 1930, 51: 356–360.
8. Bourne, W., and Raginsky, B. B. The effect of avertin upon the normal and impaired liver. Am. J. Surg., 1931, 14: 653–656.
9. Idem. Vinyl ether (vinethene) anesthesia in dogs: effects upon normal and impaired liver. Brit. J. Anæs., 1935, 12: 62–69.
10. Bourne, W., and O'Shaughnessy, P. E. The Etherington-Wilson technique in intrathecal segmental analgesia. Canadian M. Ass. J., 1936, 35: 536–540.
11. Bruger, M., Bourne, W., and Dreyer, N. B. The effects of avertin on liver function; the rate of secretion and composition of the urine; the reaction, alkali reserve, and concentration of the blood; and the body temperature. Am. J. Surg., 1930, 9: 82–87.
12. Embden, G. Ueber die Wege des Kohlenhydratabbaus im Tierkoerper. Klin Wchnschr., 1921, 1: 401–403.
13. Etherington-Wilson, W. Intrathecal nerve root block. Some contributions and a new technique. Proc. Roy. Soc. Med., 1933–4, 27: 323–331.
14. Gurd, F. B., Vineberg, A. M., and Bourne, W. Our experiences in the employment of spinal anesthesia for thoracoplasty. J. Thoracic Surg., 1938, 7: 506–511.
15. Mann, F. C., and Magath, T. B. The production of chronic liver insufficiency. Am. J. Physiol., 1922, 59: 485.
16. Melville, K. I. Combined ephedrine-pituitary extract (posterior lobe) therapy in histamine shock. J. Pharmacol. & Exper. Therap., 1932, 44: 279–293.
17. Nothmann, M., and Wagner, A. Ueber die Wirkung von Alkalisalzen im Hinblick auf die Ausloesung tetanischer Symptome beim gesunden erwachsenen Individuum. Arch. f. exper. Path. u. Pharmakol., 1924, 101: 17–27.
18. Nothmann, M., and Guttmann, E. Ueber die Wirkung der Anionen insbesondere des Phosphations auf die elektrische Erregbarkeit. Arch. f. exper. Path. u. Pharmakol., 1924, 101: 28–35.
19. Pratt, C. L. G. Ether narcosis and carbohydrate metabolism. Proc. Roy. Soc. Med., 1938, 31: 971–978.
20. Raginsky, B. B., and Bourne, W. Effects of cyclopropane on th - normal and impaired liver. Canadian M. Ass. J. 1934, 31: 500–501.
21. Idem. Action of ephedrine in avertin anesthesia. J. Pharmacol. & Exper. Therap., 1931, 43: 209.
22. Ronzoni, E., Koechig, I., and Eaton, E. P. Ether anesthesia. III. Rôle of lactic acid in the acidosis of ether anesthesia. J. Biol. Chem., 1924, 61: 465–492.
23. Rosenthal, S. M., and Bourne, W. The effects of anesthetics on hepatic function. J. Am. M. Ass., 1928, 90: 377–379.
24. Roscher, F. Investigations of postoperative acidosis and ketonuria. Acta chirurg. Scand., 1933, 74: Supp. 29: 1–238.
25. Stehle, R. L., and Bourne, W. Concerning the mechanism of acidosis in anesthesia. J. Biol. Chem., 1924, 60: 17–29.
26. Idem. The effects of morphine and ether on the function of the kidneys. Arch. Int. Med., 1928, 42: 248–255.
27. Waters, R. M., and Schmidt, E. R. Cyclopropane anesthesia. J. Am. M. Ass., 1934, 103: 975–983.
28. Waters, R. M. Personal communication.
29. Idem. Carbon dioxide. Canadian M. Ass., J., 1938, 38: 240–243.

SYMPOSIUM ON UROLOGIC INFECTIONS

RENAL INFECTION AND NEPHROLITHIASIS

GEORGE GILBERT SMITH, M.D., F.A.C.S., Boston, Massachusetts

THE number and excellence of recent articles dealing with nephrolithiasis bear witness to the importance of this disease. It is no longer sufficient for the surgeon to remove the calculus; he must make every effort to secure satisfactory drainage of the affected kidney; he must take cognizance of the composition of the stone, so that by proper diet the patient may render his urine as unfavorable as possible for the formation of a similar stone; he must seek to uncover any metabolic disorder such as cystinurea or hyperparathyroidism predisposing to stone formation; and perhaps most important of all, he must clear up whatever infection exists in the kidney. Unless these objectives are achieved, the stone is likely to recur; and recurrent renal stone may be almost as fatal as is cancer.

These facts are well recognized, but we are far from having reached the point where we can prevent recurrence in all cases. This paper is concerned with a discussion of the infectious phase of the problem. The material upon which it is based comprises some 30 cases. These patients with renal stone were operated upon within the past 5 years, and the laboratory data are reasonably complete. Within that period, at least in our clinic, we have become much more aware of the value of chemical and bacteriological studies. Our education in this direction has in large measure been due to the co-operation of Doctor Fuller Albright, who has contributed a great deal to our understanding of the underlying causes of stone formation.

In working over this series of cases, one finds many regrettable gaps in the recording of cultures, stone analyses, and urinary findings. However, enough factual evidence has been recorded to enable us to make a number of deductions.

It is possible that infection outside the urinary tract is a factor in calculus formation; Randall (13) has shown that many renal stones develop on calcareous plaques located beneath the mucosa at the apices of the pyramids, and has reproduced this lesion in animals by the administration of stable streptococcus hemolycin leucocidin. The experiments of Rosenow, in which he brought about the formation of stone in rabbits by injecting into their blood stream streptococci from devitalized teeth, suggest another possible cause of stone formation from extrarenal foci of infection.

Aseptic stones. In this series, 5 patients had sterile urine when first examined. The stones in 4 were predominantly phosphatic in spite of the fact that the bladder urine was acid in reaction. There was no record of the composition of the fifth stone. In 4 the stones were multiple; in 1, single. One patient was proved by operation to have a parathyroid tumor. Although this small series of cases does not show it, we believe that many oxalate stones are not infected when first seen.

A discussion of the causation of aseptic calculi does not come within the scope of this paper. We must recognize the fact that in perhaps the majority of cases of nephrolithiasis, urine from the affected kidney shows no growth. Schneider, in a series of 181 stones, both renal and ureteral, found the urine infected in but 57.

Bacillus coli. When we considered the bacteriological findings, both pre-operative and post-operative, in these 30 patients, we found that the Bacillus coli was the most frequent invader. It occurred 17 times, chiefly in conjunction with other bacteria and following operation. In 4 patients the Bacillus coli was found alone at the first examination; the calculus in 1 of these patients was phosphatic, in another it was composed of uric acid. There was no record of its composition in 2. Fisch states that Bacillus coli infection tends to form stones of calcium oxalate. It is my impression that as regards the problem of recurrent stone, the Bacillus coli is of no great importance. The organism can usually be killed by mandelic acid or prontylin, or even by methenamine plus acidification, provided there is good renal drainage. None of the patients with recurrent stones showed the Bacillus coli alone. Von Illyès says that the Bacillus coli can reduce the acidity

From the Urological Department, Massachusetts General Hospital.

Presented in the Symposium on Urological Infections, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

of the urine (an important factor in the formation of recurrent stone), but clinical experience seems to show that it is not an organism to be feared.

Bacillus proteus. The organism next in frequency to the Bacillus coli was the Bacillus proteus, public enemy No. 1 in the field of renal stone. We found it in 13 of our 30 patients. In only 4 instances was it present in pre-operative cultures; in the remaining 9 it appeared at varying intervals after operation. There were 5 patients whose kidneys were drained by a nephrostomy tube who did not develop a proteus infection, and 5 in whom the proteus first appeared after a nephrostomy. Seven pyelotomies without renal drainage were done; none of these developed a proteus infection. Fuller Albright has said that he has seen no instance of proteus infection in a patient who had not been subjected to urological instrumentation. In this series there were 2 patients who showed the Bacillus proteus in ureteral specimens at the time of their first cystoscopic examination. Both were women who had borne children, so it is possible that they might have been catheterized at some time in the past. We believe, however, that primary proteus infection may occur, and we shall continue to search for an example of this which shall be beyond question.

It is disturbing to believe that so useful a procedure as nephrostomy may carry with it the danger of introducing the Bacillus proteus. Some of our urological staff hold the opinion that the continued presence of a rubber tube within the kidney is in some way responsible. It seems to me that the most probable explanation of the development of a Bacillus proteus infection after nephrostomy is that the organisms gain entrance to the kidney pelvis through the open channel of the tube during the postoperative period. We have not always been careful to keep the outer end of the tube free from contamination; and in a ward where there are always several patients with proteus infection, the bacillus may be introduced through careless handling of the tube, through irrigations, or by letting the tube lie in infected urine.

Recent infections by the Bacillus proteus usually have not been difficult to eradicate, provided one realized the situation and at once applied the proper measures. The nature of these measures will be considered later.

A case which illustrates the importance of a proteus infection is that of a man 57 years of age who in October, 1937, had a stone removed from his left kidney by pyelotomy. He was operated upon at another hospital, so we have not all the details of his history; but we do know that the stone was composed of a nucleus of uric acid and an outer layer of carbonates. The uric acid must have been precipitated from an acid urine; the uric acid stone may then have led to infection, an alkaline urine, and finally precipitation of carbonates. The surgeon found some constriction at the ureteropelvic junction which he dilated. Following operation the patient was given prontylin for 5 days, was put on an acid-ash diet, and had the renal pelvis lavaged a number of times. His bladder urine, which he tested frequently, remained acid. We do not know about the urine from his left kidney. In July, 1938, 9 months after his operation, x-rays showed a 2 by 1 centimeter calculus in the left renal pelvis. A pyelogram showed a definite dilatation of the pelvis, with apparent narrowing at the ureteropelvic junction. The urine from the right kidney showed a hydrogen ion concentration of 5.0, that from the left a hydrogen ion concentration of 7.5. The Bacillus proteus in pure culture was obtained from the left kidney. Both renal functions were good.

On September 9, 1938, the stone was removed through a pyelotomy incision, and proved to be composed of phosphates. A plastic was done on the ureteropelvic junction and the pelvis drained by a No. 24 French catheter drawn through the cortex. This was removed in 12 days, as it was not draining too well; the sinus closed promptly. Between September 15 and 20 the patient was given 240 grains of sulfanilamide, but did not tolerate it well. An intravenous pyelogram on September 29, 3 weeks after operation, showed some dilatation of the pelvis. A left ureteral specimen on September 30 was slightly cloudy, with 30 to 50 pus cells per high power field. The hydrogen ion concentration was 5.5. The culture showed the Bacillus proteus and the Bacillus coli.

In vitro studies on the susceptibility to prontylin of his strain of Bacillus proteus, as advocated by Long and Bliss, showed the following results: With an inoculation of about 200 organisms per cubic centimeter of urine, bacteriostasis started at 100 milligrams of prontylin per 100 cubic centimeters; the bacteria were killed by 500 milligrams per 100 cubic centimeters but not by 300 milligrams. The pelvis was irrigated and 1 per cent mercurochrome instilled. The patient was discharged from the hospital October 1 with instructions to force fluids, to take an acid-ash diet, methenamine and ammonium chloride, and to return for observation and possibly further pelvic lavage. If other measures fail, another more heroic trial of prontylin therapy would be considered.

Of the 5 patients in this series with recurrent stones, 4 were infected with the Bacillus proteus. One was a typical stone-former. In February, 1935, this patient passed a stone from his left kidney. In November of the same year, left ureterolithotomy was done; in February, 1936, a left pyelolithotomy; in October, 1936, a right nephrolithotomy. Eventually the Bacillus proteus and the Bacillus coli infection cleared up under prontylin and mandelic acid therapy; but the left kidney showed no excretion of skiodan and by retrograde pyelography irregular, dilated calyces were demonstrated.

Cases similar to this can be called to mind by any urologist. Perhaps one kidney has been destroyed by repeated attacks of stone and has had to be removed. The other kidney meanwhile has become infected and possibly has required a permanent nephrostomy to keep it functioning at all. Stones continue to form; the renal tissue, due to infection and poor drainage, becomes increasingly inadequate. It is amazing to see, on the autopsy table, how little renal tissue suffices to support life. In most cases of this type I believe

you will find Bacillus proteus. On reviewing the history of the patient, you may find one critical moment when a more determined effort to clear up the infection, more radical surgery for the improvement of renal drainage, or even nephrectomy might have saved the second kidney from disaster.

The chief reason why a proteus infection is so troublesome is that this bacillus is one of the most active of the urea-splitting organisms. The importance of these bacteria was pointed out years ago by Rovsing, who found that 71 per cent of all recurrent stones developed in kidneys which were infected primarily or secondarily by organisms with this characteristic. Hager and Magath in 1926, wrote an excellent paper on the rôle of the Bacillus proteus in alkaline cystitis. Hellstroem has found that if sterile urine is inoculated with the Bacillus proteus and incubated, it becomes alkaline and crystals of ammonium and magnesium phosphates are formed. In kidneys infected with this organism, calculi composed of triple phosphates may form very rapidly, sometimes within a few months. Occasionally one finds a Bacillus proteus which grows in an acid urine. In determining this point, one must not accept the reaction of the bladder urine at its face value. The acidity of the total urine may be due to a highly acid urine from the uninfected kidney, whereas that from the infected kidney is definitely alkaline. This evidence is easily obtained by means of nitrazene paper, and should be routinely checked whenever ureteral specimens are obtained.

The significance of these infections has been emphasized in all recent articles on renal stones. Twinem, writing on recurrences after operations for nephrolithiasis, says that in 10 cases of this type, he found the Bacillus proteus in 6, staphylococcus in 2, the Bacillus lactis aerogenes in 1, and the Bacillus proteus and the Bacillus fluorescens in 1. Barney and Sulkowitch give an excellent sumary of the situation.

Staphylococcus. In 6 patients, the staphylococcus was found in the stone-bearing kidney prior to operation. In 1 of these patients, it was in combination with the Bacillus proteus. In the kidneys from which it was obtained in pure culture, the calculus was composed of phosphates in 2, of oxalates in 1. In 2 of these patients a primary nephrectomy was done. In the other, the urinary infection cleared up after operation.

The staphylococcus is often referred to as one of the urea-splitting bacteria. Pillet and Hellstroem have demonstrated this; Eisenstaedt tested 23 strains of staphylococci for this characteristic and found that 7 strains were definitely able to split urea. Ammonium carbonate was formed. In the cases we are reporting, the staphylococcus has not been associated with recurrent stones. Albright is under the impression that the Staphylococcus albus splits urea and is susceptible to prontylin, whereas the Staphylococcus aureus is not a urea-splitter and is prontylin resistant.

Fig. 1. Recurrent phosphatic calculus.

Bacillus pyocyaneus. The Bacillus pyocyaneus occurred once. The patient showed bilateral renal calcification. His cultures showed in addition the Bacillus proteus, the Bacillus coli, and the alpha hemolytic streptococcus. After 2 series of treatments with prontylin, the above organisms disappeared, leaving the Bacillus pyocyaneus in pure culture. Intensive treatment lasting a full year failed to clear up this infection.

Roedelius reports a case of recurrent stone formation after pyelolithotomy in which the Bacillus pyocyaneus was the infecting agent. The first stone was an aseptic oxalate calculus; Roedelius believed that the Bacillus pyocyaneus entered the kidney by way of the drainage tract, starting from an unsterile, urine-soaked, outer dressing. The second stone was phosphatic, although the urine was acid. All known measures directed toward eradicating this organism were tried without success and eventually nephrectomy was done. The kidney showed a number of small abscesses,

Fig. 2. A pyelogram obscures the calculus and shows a constriction at the ureteropelvic junction.

Fig. 3. An intravenous pyelogram 3 weeks after removal of stone.

the pelvic mucosa was raw and in places necrotic. A somewhat similar case had been reported by Fraenkels who, according to Roedelius, was the first to describe the serious consequences which might follow infection by the Bacillus pyocyaneus. That it is not always so pathogenic is shown by a patient recently examined, from whose ureteral specimens the Bacillus pyocyaneus was grown in pure culture. In spite of a considerable degree of lower ureteral obstruction due to cancer of the cervix and radiation, this patient showed little evidence of toxicity or of renal damage due to infection.

Although they are not included in this series, I would like to mention 3 cases of renal infection with an organism thought to be the Bacillus influenzæ. These have already been reported by Fuller Albright. Two of these patients showed bilateral stones with a tendency to calcification of the kidney tissue. The third, who was the wife of one of these, had a bilateral infection with the same organism but with no calculi. The urine of the 2 patients with stones was alkaline; the stones were phosphatic.

The treatment of renal infection for the purpose of preventing recurrent stone formation resolves itself largely into the eradication of the Bacillus proteus. The bacteria which do not split urea are relatively unimportant as regards stone formation; as a matter of course every infection should be cleared up if it is possible to do so. The staphylococcus infections have usually disappeared after the removal of the stone. If they persist, I believe that intravenous administration of 0.3 of a gram of neo-arsphenamin every 3 to 5 days for 4 to 6 treatments, is highly effective. I have used this treatment only in 3 cases, but in every instance the infection cleared up. It is advised by Braasch, Anson Clark, Keyser, and other urologists of experience.

The treatment of the Bacillus proteus infections may be divided into its medical and its surgical phases. The use of drugs such as mandelic acid and methenamine, which are active only in highly acid urine, is of course irrational, since it is very difficult to alter the urinary reaction when urea-splitting organisms are involved. Our most effective acidifier, ammonium chloride, simply provides more urea for the bacteria to act upon. Chute has cited an instance in which stone recurred very quickly following its use in a kidney infected with the Bacillus proteus. Sulkowitch has suggested the use of strontium chloride; Sisk has employed gluconic acid.

Fig. 4. Bilateral calcification of the kidney due to the Bacillus influenzæ.

Fig. 5. Bilateral calculi in a horseshoe kidney. The largest stone has been removed from the right kidney and a tube has been left in the pelvis. The stone on the left has caused the destruction of that kidney.

With the introduction of prontylin, the need for an acidifying agent has seemed less urgent. Reports as to the success of this drug have been somewhat conflicting. In my own experience, the infection has yielded to a relatively small dose—40 grains a day—with improvement evident 4 or 5 days after treatment was started, or the infection has not yielded at all. I must confess that in some instances my courage has not been equal to the occasion; I have been so terrified by the appearance of the patient who is blue, apathetic, sometimes almost comatose, that I have not had the hardihood to continue the drug. Having had one man of 75 years of age almost die from a bronchopneumonia, which seemed to be directly due to such a state as this, and still carry his proteus infection, I have become a half-hearted therapeutist so far as large doses of prontylin are concerned.

A highly satisfactory discussion of the mode of action and the clinical use of sulfanilamide in urinary tract infections has been published recently by Long and Bliss. They suggest that the effect of sulfanilamide upon the particular strain of bacteria should first be tested *in vitro*. When the lethal concentration has been ascertained, one is in a position to give the drug in quantities sufficient to produce the same concentration in the urine. About one half of the organisms tested were inhibited in their growth by a 50 milligrams per cent concentration of sulfanilamide, and practically all were inhibited by a concentration of 200 milligrams per cent. Since they found that only about 50 per cent of sulfanilamide is excreted in the active form, to obtain the latter strength, a dosage of 120 grains of sulfanilamide per day with a urinary output of around 2000 cubic centimeters would be required. Four strains of the Bacillus proteus were tested *in vitro* by these authors. Even with a concentration of 200 milligrams per cent sulfanilamide, bacteriostasis was only slight in 2, and moderate in 2. This concentration was not bactericidal in any of the strains.

Since, therefore, we have no reasonably certain internal medication upon which we can rely, we must turn to the direct application of therapeutic media to the kidney pelvis. This may be done through the ureteral catheter, or through a nephrostomy tube. Randall (12), in 1932, suggested the use of 1 per cent phosphoric acid in the renal pelvis as a deterrent to the activity of the urea-

splitting bacteria. He obtained a number of cures by this method. Von Illyès employed silver nitrate; Albright has suggested the use of a solution of sulfanilamide as a pelvic irrigation.

Of the 13 patients with the Bacillus proteus infection, 2 had primary nephrectomies and their urine became sterile. One, however, has passed a stone from his remaining kidney. Three had secondary nephrectomies, all about one year after the first operation. All 3 had obstruction at the ureteropelvic outlet; their kidneys were in various stages of disintegration. Stone had recurred in 1; in another, 2 fragments left behind at the first operation showed little increase in size. These patients had had nephrostomies, but were victims of faulty drainage. Four that had nephrostomies got rid entirely of their infection. One patient who had a nephrostomy remains infected; one is still in the hospital but with a strongly acid urine he promises to become free from infection. One was cured by sulfanilamide and mandelic acid. In one the Bacillus proteus continued in spite of sulfanilamide; 100 grains a day for 8 days were administered.

The surgical measures to be employed in patients with infected, stone-bearing kidneys are various and should be based upon a thorough knowledge of the facts. The size, shape, and distribution of the stones, the separate functions of the kidneys, the type of infection present, the condition of the other kidney, all influence one's treatment of the diseased organ. Two ends must be kept in mind, prevention of stasis and eradication of infection. If it appears unlikely that all fragments can be removed, nephrectomy should be considered if the other kidney is sound; for in my experience it is seldom that one can sterilize a kidney in which are left pieces of stone. This rule is not absolute, of course, but generally speaking a bit of infected stone is a sure cause for recurrence. The same principle holds in cases of stasis; even if the kidney is not infected previous to operation, it probably will become so afterwards. With a kidney which shows a marked degree of hydronephrosis, the operator should consider nephrectomy. *Conservative* renal surgery, about which so much has been written, is eminently desirable; but a better guarantee of future health is to remove a kidney which has too many potentialities for getting into trouble. If the upper or lower calyx is dilated, resection of the corresponding renal pole is a wise precaution.

Nephrostomy is a time-honored procedure which has been thought well of by many urological surgeons. Cumming, writing on the value of prolonged nephrostomy drainage after removal of calculi, cited von Lichtenberg, Chute, Cabot, Bugbee, Winsbury-White, Papin, and Crosbie as favoring nephrostomy in some instances for long periods. Counseller and Hoerner agree that nephrostomy aids the eradication on infection and the restoration of function. After analyzing a series of 187 patients operated on for renal stone at the Mayo Clinic in the years 1929 to 1933, these authors concluded that the results when nephrostomy was done were better than those when it was not done, despite the fact that the kidneys subjected to drainage were more severely damaged originally.

Von Illyès, writing on recurrent calculi, said that he had 6 per cent recurrences after 81 nephrotomies, against 8.7 per cent recurrences in 510 cases of pyelotomy or ureterotomy. He comments on the value of transrenal drainage when clots are present, especially if infection exists, and in kidneys with dilated, stiff-walled calyces. It is his custom to remove the tube in 6 to 8 days.

In the series of cases upon which this paper is based, a catheter was drawn through the renal cortex into the pelvis in 11 patients. The tube was left in for 12 or 14 days in almost all of these cases, but in one patient it was left for 4 months.

The value of prolonged kidney drainage is illustrated by the following history:

> The patient, a man 44 years of age, entered the Baker Memorial Hospital on January 20, 1936, with an anuria of 5 days' duration; his non-protein nitrogen was 125 milligrams per cent. X-rays showed a horseshoe kidney, the left half of which had been destroyed by a stone impacted in the upper ureter. On the right there were 4 stones, one 3 centimeters in diameter and 3 smaller ones. The ureters were catheterized; only a bougie could be passed to the left kidney. A catheter was left in the right kidney for 2 days. As drainage through this catheter was inadequate, on January 22 the large stone on the right was removed through a pyelotomy, and a catheter drawn into the pelvis through the cortex. The urine at this time showed no growth. Eighteen days after operation it showed the Bacillus coli and the Bacillus proteus and one month after, the Bacillus proteus alone. Three weeks after the operation upon the right kidney, the left kidney, which was found to be functionless, was removed. The patient was discharged from the hospital with a catheter in the right kidney; this catheter he kept closed, but he irrigated his renal pelvis twice a day with potassium permanganate. He took picochrome orally for 4 weeks, then methenamine. Three months after his first operation he passed the 3 small stones that had been left in the kidney. Four months after operation his urine was clear and constantly acid; the catheter was removed for good, having been changed several times in the meantime. For 2½ years he has been under observation. No new stones have formed and his urine is acid and free from pus.

The employment of nephrostomy in an infected kidney is in accordance with surgical principles. It provides free drainage, which is essential in the clearing up of infection. It enables one to

wash out old blood clot, bits of fibrin and necrotic tissue, and to irrigate the renal pelvis with bactericidal solutions, with those designed to change the reaction of the urine, and with those calculated to dissolve the bits of crystalline material which may be adherent to ulcerated areas in the pelvis or calyces. All these factors are important in preventing the formation of new stones, and in bringing about the sterilization of the kidney. I am not sure that it matters greatly what solution is employed. Potassium permanganate, 1:3000, is a good solvent of mucus; mercurochrome, boric acid, silver nitrate, phosphoric acid, acriflavine, and doubtless many other solutions have been used. The mechanical effect is probably the most important.

The same holds true with postoperative lavage of the renal pelvis through a ureteral catheter. This measure is often neglected, but I believe it to be of great value in certain situations. It is especially useful if there is any question of obstruction to drainage, both because of the effect of irrigation and that of dilatation. Keyser emphasizes the latter effect; he dilates the ureter, sometimes to a No. 16 French catheter.

If simple pyelotomy is done, one should not discharge the patient until his urine is sterile. The administration of appropriate urinary antiseptics and if necessary, lavage of the renal pelvis, should be continued until the infection is eradicated.

CONCLUSIONS

1. Renal infection is not a factor of major importance in the formation of the majority of primary renal calculi.

2. In the formation of recurrent stone, with the exception of those due to hyperparathyroidism and to cystinuria, infection is of the greatest importance.

3. In such cases, the Bacillus proteus is the organism most commonly found.

4. The urologist's duty is not fulfilled with the removal of the stone; he must then employ every possible known measure to eradicate the renal infection.

5. In order to do this successfully, he must vary his surgical procedure according to the circumstances of the case. This may mean nephrectomy, partial nephrectomy, nephrostomy, or pyelotomy.

6. No case of renal stone should be regarded as satisfactorily concluded until the urine has become sterile.

REFERENCES

1. ALBRIGHT, F. Personal communications.
2. BARNEY, J. D., and SULKOWITCH, H. Progress in the management of urinary calculi. J. Urol., 1937, 37:746–761.
3. COUNSELLER, V. S., and HOERNER, M. T. Analysis of effectiveness of nephrostomy in treatment of large calculi. J. Urol., 1936, 35:21–31.
4. CUMMING, R. E. The treatment of bilateral renal and ureteral calculi. J. Urol., 1934, 32:600–623.
5. EISENSTAEDT, E. J. S. Discussion. J. Urol., 1934, 31:251–253.
6. FISCH. Quoted by von Illyès. (v. infra).
7. HAGER, B. H., and MAGATH, T. B. The formation of vesical calculi. J. Am. M. Ass., 1928, 90:266–271.
8. HELLSTROEM. Quoted by von Illyès.
9. KEYSER, L. D. Recurrent urolithiasis; etiologic factors and clinical management. J. Am. M. Ass., 1935, 104:1299–1306.
10. LONG, P. H., and BLISS, E. A. Observations upon the mode of action and the clinical use of sulfanilamide in urinary tract infections. South. M. J., 1938, 31:308–315.
11. PILLET. Quoted by von Illyès.
12. RANDALL, A. Prevention of the recurrence of urinary calculi. Am. J. Surg., 1932, 18:482–493.
13. Idem. Studies on the pathology of the renal papilla. J. Am. M. Ass., 1937, 109:1698–1702.
14. ROEDELIUS, E. Unusual pyocyaneus infection of urinary passages with new stone formation following pyelolithotomy. Deutsche Ztschr. f. Chir., 1936, 248:167–173.
15. ROSENOW, E. C. Production of urinary calculi by devitalization and infection of teeth in dogs with streptococci from cases of nephrolithiasis; summary of results. Illinois M. J., 1926, 49:28–33.
16. SCHNEIDER, E. Primary and secondary aseptic nephrolithiasis. Med. Klin., 1937, 33:1089–1092.
17. TWINEM, F. P. Recurrence after operations for nephrolithiasis. J. Urol., 1937, 37:259–267.
18. VON ILLYÈS, G. Recurrent calculi; frequency and causes. J. d'urol., 1934, 38:419–432.

PYELONEPHRITIS AND ITS TREATMENT

WILLIAM F. BRAASCH, M.D., F.A.C.S., Rochester, Minnesota

BEFORE we go any further, let us first get straight what we mean by the term pyelonephritis. It is generally recognized that there are two distinct types of renal infection, namely, a primary hematogenous infection, predominating in the renal cortex, and a lesion predominating in the central portion of the kidney, which is usually called pyelonephritis. The path of infection with pyelonephritis is generally regarded as ascending rather than blood borne and the bacteria usually belong to the bacillary group. To repeat, there are two distinct types of renal infection: type 1, the cortical, hematogenous infection, often requiring surgical treatment; and type 2, pyelonephritis, usually ascending from the lower levels of the urinary tract, with predominant bacillary infection, and seldom requiring surgical treatment.

The subject of renal infection, however, is not as simple as this schematic outline would suggest, since many variations and a mingling of the two types are often observed. Nevertheless, there are definite clinical data which differentiate these two groups and which should be recognized in the clinical consideration of the subject. The type of renal infection that I am discussing is the ascending form of infection, or pyelonephritis. If pyelonephritis is an ascending infection, how does it get up into the kidney from the genitalia and lower urinary tract? That is a problem which remains unsolved. However, the two most probable avenues are through the ureter and through the lymphatics. How can the infection ascend directly up the ureter in the face of peristalsis? This is explained by a combination of possible back-pressure, incompetent ureterovesical valve, and reverse peristalsis, the latter occurring more frequently than is generally realized.

TYPES OF PYELONEPHRITIS

In the discussion of pyelonephritis let us recognize that there are three clinical phases of this disease: namely, the acute, recurring, and chronic forms. Acute pyelonephritis is by far the most common lesion in the genito-urinary tract. In fact, next to respiratory infection, it probably is more common than infection in any other field.

From the Section on Urology of The Mayo Clinic.
Presented in the Symposium on Urological Infections, before the Clinical Congress of the American College of Surgeons New York, October 17–21, 1938.

Pyelonephritis occurs more frequently in the female in its acute form and more often in the male in its chronic form. This is due to the greater susceptibility of the urinary tract in the female to acute ascending infection and, on the other hand, to the fact that there are chronic foci of infection in the prostate and adnexa which are the usual basis for chronic pyelonephritis in the male. Most cases of acute pyelonephritis in either child or adult are of short duration and are self-limiting. The medicine we give these patients is often given credit for clearing up infection which in reality has been overcome by natural resistance. However, when the infection persists longer than 4 or 5 days and when it is accompanied by fever and chills, nature is materially aided by the administration of any of the various chemotherapeutic agents now available.

The second form of pyelonephritis to be considered is characterized by recurring attacks of acute pyelonephritis. The periods of infection may persist over several weeks or months and recur after a variable lapse of time. In the interval, although the patient is free of symptoms, careful and persistent search of the urine will often show the presence of a few bacteria, indicating that the renal infection in most of these cases is dormant rather than eliminated.

The third type of pyelonephritis is its chronic form and this is the most difficult to overcome of the three. The first two types of renal infection usually will respond to recently developed chemotherapy and control of the etiological factors, but chronic pyelonephritis offers an entirely different problem. In using the term chronic pyelonephritis I refer only to those cases in which renal infection has persisted over a period of at least 1 year. Chronic pyelonephritis involves both kidneys, with rare exceptions. In fact, when only one kidney is found to be infected over a long period of time, it can be assumed that a secondary complication is present which in most cases will necessitate surgical treatment. Chronic pyelonephritis often runs a course of many years without great curtailment of life or its activities. Unless complications occur, patients usually suffer only from dysuria and frequency and in many cases become inured to it. In about 20 per cent of cases immunity is developed and the infection is gradually

eliminated. In others, however, such complications develop as secondary lithiasis, hematuria, and ureteral or pelvic obstruction as the result of cicatricial deformity. In still other cases the infection and cicatricial changes in the renal tissue curtail glomerular activity so that the renal function suffers materially, with the usual symptoms. In a few cases this destructive process is confined to one kidney and the condition may then require surgical treatment.

There is no doubt that the infecting organism in the female ascends through the urethra into the bladder much more frequently than is generally recognized. Countless women who complain of urinary frequency and dysuria—the so called irritable bladder—in most cases will be found on endoscopic examination to have evidence of infection in the urethra. The treatment in these cases should start with elimination of vaginal infection, chronic cervicitis, and infection in the periurethral glands and tissues. Urethritis, so often overlooked, lends itself readily to such simple treatment as dilatation of the urethra if this is found to be cicatricial, and the application of antiseptics, such as protargol or argyrol, by means of urethral suppositories or tampons. Urethritis is frequently accompanied by an eroded or prolapsed urethral mucosa. This should be treated by a combination of local applications and soothing ointments, never by cautery. Of primary importance also is the elimination of all possible distant foci of infection. By taking these simple precautions in the female, most cases of persisting or recurring acute urinary infection can be overcome. Similarly in the male, recurring attacks of pyelonephritis can usually be traced to a persistent, virile infection in the prostate. In curbing reinfection, the usual treatment of massage is greatly aided by liberal doses of sulfanilamide compounds.

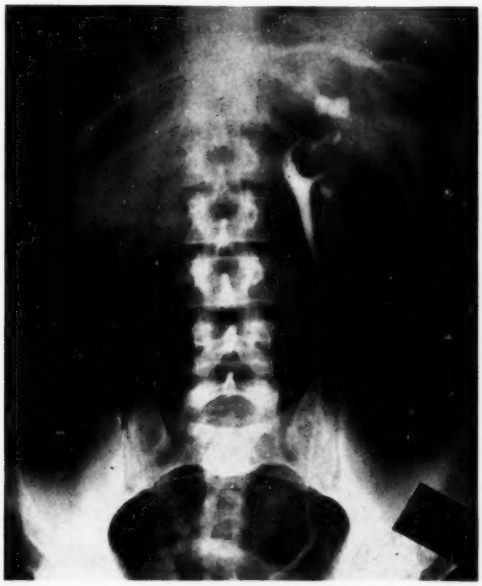


Fig. 2. Bilateral pyelonephritis with cicatricial changes in pelvis of left kidney, characterized by constriction of infundibulum and bulbous enlargement of upper calyx. Contraction of other calyces.

Fig. 1. Chronic bilateral pyelonephritis. Deformity predominant in ureter, characterized by cicatricial irregularity and atonic dilatation in the upper third.

Another form of renal infection which assumes the clinical character of a glomerular nephritis rather than that of pyelonephritis is sometimes observed and requires special consideration. Although the clinical data resemble those accompanying nephritis and are frequently influenced by a variable degree of renal insufficiency, nevertheless its infectious nature is disclosed by the presence of pus cells in the sedimented urine; and with persistent effort and refined methods of culture, bacteria can often be found. Its infec-

Fig. 3. Bilateral pyelonephritis. Cicatricial changes involving calyces, characterized by constriction of infundibula and clubbing of lower calyx. Atonic dilatation in the lower segment of ureter on both sides.

tious nature is corroborated by the fact that the administration of sulfanilamide and its derivatives has been followed by definite improvement. Although these drugs may not be eliminated in the urinary tract when the renal function is reduced, nevertheless their systemic action may have a bactericidal effect. I have observed a number of patients with acute exacerbation of renal infection accompanied by renal insufficiency who could not tolerate oral administration, but who improved to a marked degree following the subcutaneous injection of prontosil and sulfanilamide.

Retention of urine is a common and often serious complication following intra-abdominal and pelvic operations. It almost invariably follows resection of the lower bowel for malignant lesions, because of temporary injury to the innervation of the bladder. Unless the retention is relieved, distention of the bladder with renal back-pressure and infection will result. Catheterization is usually necessary and should be done promptly. Otherwise secondary infection, which usually follows, will ascend to the kidneys. By the simple expedient of giving the patient 5 grains, or 0.3 grams, of sulfanilamide 3 or 4 times a day, starting immediately after the operation, renal infection from postoperative catheterization usually can be overcome.

In the treatment of recurring or chronic renal infection the first step to take is to make sure that the infection is primary and not secondary. Pyelonephritis which is secondary to some underlying lesion such as stone, tuberculosis, or obstruction in the bladder or ureter probably occurs more frequently than does primary renal infection.

These factors having been excluded, the next thing is to determine the type of bacteria present. If there is any one thing that has been learned in the development of modern therapy of urinary infection, it is the necessity of a working knowledge of bacteriology.

It would seem that necessity has made bacteriologists out of urologists, or to be more accurate, has made urological bacteriology. For the purpose of the average clinician, however, it is necessary to be familiar with only a few simple observations in bacteriology. Microscopic differentiation between the two main groups of bacteria, namely, bacilli and cocci, is essential to adequate diagnosis.

Fig. 4. Bilateral pyelonephritis. Cicatricial changes in calyces, with bulbous enlargement of all calyces and atonic ureteral dilatation in the lower segment of the right ureter.

Why is it necessary to differentiate the bacteria? For the simple reason that some bacteria respond better to certain drugs than to others. It is true that it may not be necessary to know the exact bacteria involved if the infection yields readily to routine chemotherapy. However, this is not the rule, and when the infection persists or recurs a bacterial study is essential to successful treatment. The main types of bacteria can be recognized easily and without elaborate laboratory facilities. For practical purposes the simple Gram stain of the dried urinary sediment may suffice. Microscopic examination will readily determine the presence of cocci or bacilli and whether they are gram-negative or gram-positive. Although gram-negative bacilli are most commonly observed with pyelonephritis, any type of bacterium may be present and in many cases the bacteria are mixed.

When it is desirable to identify the various types of gram-negative bacilli, cultures can be made from the urinary sediment. The 3 bacilli which occur most frequently and have the greatest clinical significance are the colon bacillus, its tough little cousin aerogenes, and the tenacious Bacillus proteus. It is desirable to distinguish the latter because it splits urea, causes alkaline urine, and may be hard to eliminate. Of the cocci the gram-positive cocci, including staphylococci, are more frequently seen than streptococci. One form of streptococcus, however, the weakly Streptococcus fæcalis, is frequently found in the urine, either alone or more often in conjunction with bacillary infection. It can usually be recognized by its shape and its peculiar appearance with the Gram stain.

Let me warn the readers, however, about one thing: Just because the patient's symptoms disappear and there is no longer pus in the urine, it does not mean that the infection is completely eliminated. Time and time again I have seen symptoms disappear completely after a short course of treatment; microscopic examination of the urine revealed no pus cells and the patient was allowed to go rejoicing. Within a few weeks or months, however, the symptoms recurred and often an acute infection followed. This could have been obviated easily by remembering the fact that bacillary infection frequently persists when symptoms and pus cells disappear. It is essential, therefore, in the employment of any form of treatment, that Gram stains or cultures of the urine be made for some time after the symptoms disappear and that the treatment be continued for several days after cultures have become negative.

RECENT DEVELOPMENTS IN THE TREATMENT OF URINARY INFECTION

In no other field of medicine has there been a more revolutionary change in therapy than has taken place during the last 3 years in the treatment of infections in the urinary tract. Recent developments in chemotherapy have completely altered our theories and methods of treatment. The genesis of these recent therapeutic agents reads like a romance. Progress from acidification of the urine to the ketogenic diet and the use of mandelic acid in the treatment of urinary infection now seems logical and simple, but in reality it represents giant strides.

Mandelic acid is being largely replaced by the more efficient sulfanilamide-like compounds. Its use is limited largely to certain bacillary infections and it is effective only when the urine is made highly acid, which in itself is often either objectionable or impossible. However, occasionally it will eliminate bacilli when the sulfanilamide compounds fail to do so, and it is peculiarly bactericidal against Streptococcus fæcalis. Occasional cases are observed in which bacillary elimination is possible only by the combined use of mandelic acid preparations and a modified ketogenic diet. Mandelic acid is often used when the patient is unable to take sulfanilamide.

It was only in 1935 that Domagk discovered the bactericidal properties of prontosil with infection in mice, and soon after this the observation was applied to human infection. Since then this drug and its derivatives have swept like wild fire across the therapeutic horizon, so that today it probably is used more widely and for a greater variety of infections than any other drug in the history of medicine.

These two drugs have given us means to combat infection in the urinary tract far more efficaciously than ever before. It will be impossible in this paper to give adequate consideration to these therapeutic agents. It will be possible only to refer to some of their more important qualities and to a few recent observations which have been made on their use.

Sulfanilamide is bactericidal against all bacteria appearing in the urinary tract. Its efficacy varies in degree, however, with the type of bacteria present, the pathological condition of the tissues involved and the degree of immunity on the part of the patient. Sulfanilamide is particularly efficacious in urinary infections with the colon bacillus, Aerobacter aerogenes, proteus and their brethren. It has been a godsend in the cases of infection with proteus, which in the past has been most difficult to eradicate from the urinary

tract. It is less efficacious with coccal infections, although more often than not it will eliminate them. Sulfanilamide is almost impotent against Streptococcus fæcalis, and it will usually be necessary to fall back on mandelic acid therapy in order to eradicate this organism.

The action of sulfanilamide varies widely, so far as the patient is concerned. It is most efficient in children and in younger adults, who seldom experience any toxic reaction. In the elderly patient it should be given with care, since it seems to be far more toxic and its use is often accompanied by marked acidosis. The greatest objection to it is undoubtedly its toxic effect, which limits its use in many adults over 40 years of age.

The drug manifests its toxicity in many ways, which by this time are well known to almost everyone, such as malaise, gastric symptoms, weakness, skin eruptions, and so forth. Most dangerous and insidious are changes in the blood characterized by agranular leucopenia. It is curious that those who use it most widely and in the largest doses seem to observe less violent reactions than those who use it occasionally. It should be made emphatic, however, that where blood changes and the subjective symptoms of toxicity are apparent, its use must be discontinued immediately, or resumed with great caution and in small doses.

In regard to the tissues involved, experience has shown that sulfanilamide is not of much value in tissues which have recently been traumatized, as at operation. For instance, following renal plastic operations or transurethral prostatic resection, the drug has little or no influence on the infection in the tissues involved. However, if the infection persists a month or so after the tissues in the operative field are healed, sulfanilamide may be of value in eliminating the infection.

Sulfanilamide seems to be least efficacious with advanced chronic pyelonephritis because of secondary anatomical changes in the renal tissues. There is a vast difference in the results obtained in therapy for chronic and for recent renal infection. With chronic pyelonephritis the cicatricial changes surrounding a localized area of infection are such that the drug apparently cannot function. It is true that many patients with chronic pyelonephritis will respond to the drug to a remarkable extent and in many cases the infection may eventually be eliminated. However, when the infection is widespread, when accompanied by such complications as hematuria, secondary lithiasis, or interference with renal drainage, the chances for improvement are not too good. In former years several hundred patients with chronic pyelonephritis were observed annually at The Mayo Clinic. In spite of the fact that recent chemotherapy has been employed only a few years, the number of these patients observed today is only a fraction of that formerly seen. This reduction is probably due to two causes: first, the efficacy of chemotherapy in the uncomplicated cases of chronic pyelonephritis, and second the fact that chronic pyelonephritis is being prevented by overcoming the infection in the acute and subacute forms. There is no doubt that sulfanilamide and its derivatives have already reduced the incidence of chronic pyelonephritis and they bid fair to control if not eliminate one of the most trying diseases involving the urinary tract.

Repeated efforts have been made to modify sulfanilamide or to find substitutes which would not have its toxic qualities. Although prontosil was first employed in combating infection, it was supplanted in clinical use by sulfanilamide because the latter seemed more bactericidal. In view of the fact, however, that prontosil is less toxic, there has recently been a tendency to return to its wide employment. Modifications were made which rendered prontosil more soluble and the resulting compound is called neoprontosil soluble. This compound, which will soon be available for general use, apparently has the same bactericidal qualities as sulfanilamide, but is much less toxic. It probably will be widely employed as soon as it is released by federal authorities for general use.

It is now being realized that large doses of sulfanilamide compounds are unnecessary in many cases of infection in the urinary tract. Smaller doses, frequently as small as 5 to 15 grains, or 0.3 to 1 gram, daily, will often suffice to keep the infection under control and will usually cause no toxic reaction. This is particularly true with chronic or recurring attacks of pyelonephritis. If these small doses are administered continuously to the patient in the interval between attacks, recurrence is frequently prevented. Small doses may also be of value with chronic, inoperable pyelonephritis complicated by either primary or secondary ureteral obstruction or stone. I have observed patients suffering from advanced chronic pyelonephritis with poor renal drainage and others with extensive bilateral renal lesions and secondary renal infection, who, when given 5 grains, or 0.3 gram, of sulfanilamide daily over a period of a month, reported that the urine cleared to a large extent and that the febrile attacks were prevented. However, when

sulfanilamide is given preliminary to renal operations, it will seldom eliminate secondary renal infection unless the primary lesion is corrected.

Theoretically, it would seem that if correctly prepared, vaccines, antigens and the like should be of therapeutic value. Although vaccines were formerly employed widely in combating renal infection, as a result of unsatisfactory experiences their use has been gradually discontinued. Recently attempts have been made to modify their preparation with some success. These modifications consist largely of greater care in obtaining the infecting organism, dilution of the strain in culture, preparation of the vaccine after shorter incubation, and detoxication by means of salines. They should be of value particularly with coccal and proteus infections, which often resist all forms of chemotherapy.

Although surgical intervention is not usually indicated in the treatment of chronic pyelonephritis, certain secondary complications may develop which can be relieved only by operation. Included among these complications are ureteral obstruction causing inadequate renal drainage, unilateral infection accompanied by recurring febrile attacks which resists all forms of chemotherapy, and unilateral destruction of renal function, with renal atrophy. In a recent review of 526 cases of chronic bilateral pyelonephritis observed at The Mayo Clinic, surgical treatment was found necessary in but 17, or 3 per cent. It goes without saying that with pyelonephritis developing secondary to primary lesions such as pyelectasis and renal lithiasis it is necessary to relieve the underlying condition by surgical measures. One of the best reasons for urging early operation for renal lithiasis or hydronephrosis is that, if secondary renal infection exists too long, it may be difficult to eliminate, even if the primary lesion is removed. Attempts made to overcome primary chronic pyelonephritis by such surgical means as drainage, nephropexy, and decapsulation, as suggested by von Lichtenberg, did not meet with much success in a series of 11 patients operated on at The Mayo Clinic.

SUMMARY

Since pyelonephritis is usually secondary to infection in the lower portion of the urinary tract, treatment must be directed to this source in order to prevent recurrence.

A working knowledge of urological bacteriology is essential to the intelligent treatment of urinary infection, since some bacteria respond better to certain drugs than to others.

Elimination of pus from the urine and cessation of symptoms do not necessarily mean that infection is completely eliminated. Repeated cultures must be made subsequently to insure recovery.

Recent developments in chemotherapy have given us two compounds which are much more efficacious in the treatment of infection in the urinary tract than any other drug previously employed and often give miraculous results. They are sulfanilamide (and its related drug, prontosil) and mandelic acid. Sulfanilamide compounds should be used more frequently as a preventive of infection such as occurs with postoperative retention of urine. Its bactericidal influence in small doses is employed for this purpose and in other types of urinary infection.

With the increasing efficacy of chemotherapy and the development of special vaccines, it may be predicted that primary pyelonephritis will be largely limited to its acute and subacute stages and that chronic pyelonephritis with its complications will develop only occasionally. This will, however, entail a thorough study of all the factors involved, including the bacterial, physiological and anatomical factors.

REFERENCES

1. Domagk, Gerhard. Ein Beitrag zur Chemotherapie der bakteriellen Infektionen. Deutsche med. Wchnschr., 1935, 1: 250–253.
2. von Lichtenberg. Hydronephrosis. Am. J. Surg., 1929, 7: 747–752.

SYMPATHECTOMY FOR THE RELIEF OF VESICAL SPASM AND PAIN RESULTING FROM INTRACTABLE BLADDER INFECTION

REED M. NESBIT, M.D., F.A.C.S., and FREDERICK C. McLELLAN, M.D.,
Ann Arbor, Michigan

SYMPATHECTOMY for the relief of pain in the urinary bladder was first performed by Piere in 1926. Since that time numerous authors have reported the results obtained from the employment of this procedure. A careful review of the literature devoted to this subject fails to reveal any unanimity of opinion regarding the indications for or the limitations upon this operation, and discloses a surprising variation in the end-results of reported cases. During the past year several reports have appeared advocating various types of sympathectomy designed to relieve pain of bladder origin. It thus appears entirely proper that the subject be discussed critically in the hope that an understanding of the rationale of operation, its indications, and limitations might be evaluated. To that end a review of the literature pertinent to the subject is given, and a critical analysis of the cases here reported is presented in an effort to shed further light upon this question.

The nervous anatomy of the bladder has been ably described by many exhaustive and complete reports. We will, therefore, pass over the subject with but a brief mention of the essential pathways which comprise the innervation of the bladder and will present a résumé of its neurophysiology. The parasympathetic or sacral outflow arises from the anterior divisions of the second, third, and fourth sacral nerves (Fig. 1). These trunks pass mesially in the lower pelvis to the inferior hypogastric ganglia situated on each side of the rectum and beneath the bladder and here join the sympathetic or thoracolumbar outflow. Mixed fibers from both systems then supply the various parts of the bladder.

The sacral or parasympathetic outflow carries both sensory and motor components and supplies all the necessary reflex pathways for normal micturition. Many observers have pointed out that the sympathectomized bladder not only functions normally, in so far as micturition is concerned, but also has normal tactile, thermal, and pain sense. Denny-Brown refers to such a case in which complete sympathectomy was performed for megacolon. This patient showed no discernible alteration in urinary function. Our sympathectomized patients here reported, all showed normal sensations to touch, heat, cold, and to painful stimuli in all parts of the bladder. Interruption of the sacral (parasympathetic) pathways produces an autonomic bladder the function of which is independent of voluntary control. Dribbling incontinence with residual urine is the rule, although this bladder may develop some degree of autonomic periodic emptying. Such a bladder, innervated solely by the sympathetics, is insensitive to heat and cold, and sensation of filling is essentially abolished, although this is present in some. Pain sense is inconstant in this type of bladder.

The sympathetic or thoracolumbar outflow reaches the bladder by two routes. The route is first the presacral or hypogastric nerves which course downward in front of the sacrum as a single, or many branched nerve, or, as is generally the case, as a plexus of interlacing nerve fibers termed the superior hypogastric plexus. In the region of the hollow of the sacrum these fibers divide into two trunks termed the inferior hypogastric nerves and enter the inferior hypogastric ganglia where they are joined by the parasympathetic outflow. The second source of sympathetic fibers is tiny branches which arise from the lateral sacral sympathetic gangliated chain and also enter the inferior hypogastric ganglia.

The exact function of the sympathetic or thoracolumbar outflow is still open to debate. However, most observers agree that impulses carried by these pathways importantly regulate the tonicity of the so called internal sphincter of the bladder, the trigone of the bladder, and the ureterovesical orifices. They also regulate contraction of the prostate, seminal vesicles, and ejaculatory ducts.

Vasoconstriction of the blood vessels over the trigone area has been reported by some observers, who have further noted a vasodilatation of this

From the Department of Surgery, University Hospital.
Presented in the Symposium on Urological Infections, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

area following sympathectomy. Whether or not pain sensations are conducted over these trunks is, we feel, open to debate. Denny-Brown, Learmonth, and others have expressed the affirmative view regarding this function. Neuro-anatomists agree that somatic fibers, inconstant in number, are to be found in the hypogastric nerve bundles, accompanying the purely autonomic non-myelenated fibers. While it is accepted that these fibers may represent afferent (sensory) components, it has not been definitely established that such is the case. Surely experimental and clinical evidence does not fully support or contradict the point.

Learmonth reported having stimulated the proximal cut end of the presacral nerve during operation. His patient complained of a crushing or spasmodic pain in the region of the bladder. On the basis of this observation he concluded that the presacral nerve contained afferent components and expressed the belief that sensations of bladder spasm were conducted by these nerves. Denny-Brown had the opportunity of studying a patient who had a cauda equina lesion with complete destruction of the fourth and fifth lumbar vertebras, and all of the sacral roots. He was thought to have his sympathetics intact because he could sweat. This patient could perceive pain in his bladder. In these 2 instances it is evident that sensory components accompanied the hypogastric nerves. Riddock has also presented evidence to show that the hypogastric nerves conduct painful impulses.

Our own observations in a small series, provided contrary evidence to that quoted above.

An illustrative case (Chart I) showed destruction of the parasympathetic pathways. That the patient's sympathetics were intact was revealed by the fact that he was able to ejaculate normally and that he had a tonic internal sphincter. Electrical stimulation to all parts of his bladder failed to elicit the sensation of pain, and heat and cold sensations were likewise lacking. It is to be noted that he did have sensation of bladder distention, however. An attempt was made to induce pain from bladder spasm in this case since some authors have accredited this function to the presacral nerve. One hundred cubic centimeters of a 2 per cent unbuffered mandelic acid solution was introduced into the bladder. This solution had previously been quite accidentally introduced into a normal bladder producing spasm with paroxysms of pain and was found to produce no lasting damage to the bladder. The mandelic acid solution was introduced in this instance through a catheter, using a burrette for a reservoir. Although this autonomic bladder went into spasm, as shown by the fact that the solution was immediately forcibly expelled out through the end of the burrette, the patient suffered no discomfort and was, in fact, aware of no sensation whatever.

Identical observations have been made upon 2 other cases presenting similar cauda equina lesions. From these studies we feel justified in concluding that the hypogastric nerves may carry no afferent sensory components although in cases reported by other observers the contrary appears to be true.

This brief résumé of the bladder neurophysiology points out two essential facts pertinent to the discussion: first, that the parasympathetic pathways carry a constant and abundant supply of sensory components; and second, that the sympathetic pathways may or may not carry sensory components. It is further evident that sectioning of the sympathetic pathways alone does not interrupt the normal perception of pain in the bladder.

Complete sensory denervation of the urinary bladder has been accomplished by excision of the inferior hypogastric ganglia and by cordotomy. Removal of the inferior hypogastric ganglia was first performed by Rochet and reported in 1921. This was done for the relief of painful, tuberculous cystitis but was found to be an extremely hazardous procedure and carried the disadvantage of producing urinary incontinence. Learmonth reported that he performed this procedure for relief of pain resulting from malignancy but felt that the hazards of operation overbalanced the advantages of it. Cordotomy, occasionally resorted to for relief of bladder pain resulting from advanced malignancy, achieves this end with a minimum of risk and operative trauma. It presents the disadvantage of producing disturbances in urinary function with incontinence, but this objection should not contra-indicate its use in relieving the agonies of hopeless cancer.

Three techniques of sympathectomy have been described for the relief of bladder pain. The first operation of Piere, in 1926, consisted of simple resection of the presacral nerves (hypogastric plexus) which he performed for intractable cystitis. This operation did not provide complete relief of pain. Later, in 1930, he described a more extensive sympathectomy (Fig. 2), including division of both paravertebral sympathetic chains at the lower border of the fifth lumbar vertebra and section of the gray rami from the first, second, and third sacral ganglia to their corresponding nerves. It was felt that this procedure would interrupt more sensory pathways than presacral neurectomy alone. The third technique, a simplification of Piere's second, was recently described by Scott and Schroeder. This method consists of performing presacral neurectomy and interrupting the lateral sacral sympathetic gangliated chain by means of exeresis.

Practical experience has not demonstrated that the complete operation is more advantageous than

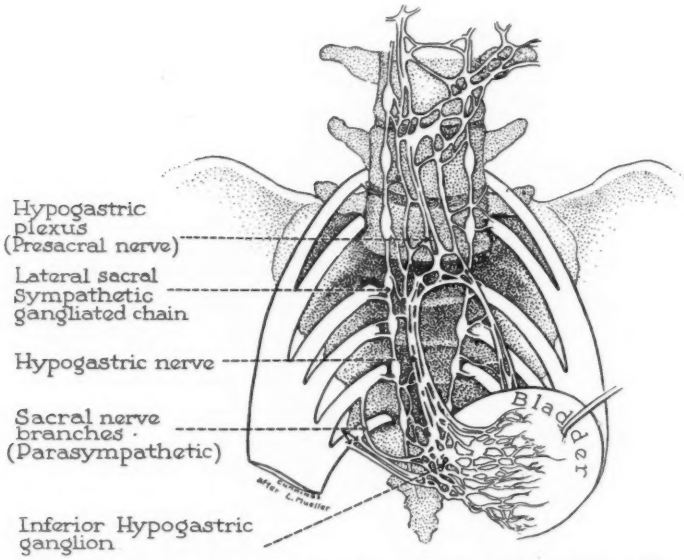


Fig. 1. Schematic view of nerve supply of the bladder. After Mueller *Lebensnerve und Lebenstriebe.*

simple presacral neurectomy. Learmonth concluded that relief of pain was obtained as effectively by the simpler procedure as by the more extensive one. Our own experience has borne out this observation.

A review of the cases reported in the literature disclosed that in the aggregate about 50 per cent of patients sympathectomized for bladder pain had, in reality, been relieved of their pain. For the purposes of critical analysis and evaluation, it is unfortunate that practically none of the reports disclosed the types of pain for which operation was performed or what types of pain were found to be relieved. The manner in which certain types of bladder pain are relieved by sympathectomy is, we believe, demonstrated by an analysis of the cases herewith presented.

CASE HISTORIES

CASE 1. A. M., No. 260733, a 43 year old housewife, had chronic pyelonephritis, intractable cystitis, with mixed, non-tuberculous infection for 9 years, which was resistant to all forms of therapy. The symptoms were: frequency rate of 15 to 30 minutes, day and night; burning and severe spasmodic pain at every urination, which was relieved only by narcotics for 2 years; and 20 to 30 cubic centimeters were voided at each urination. The cystoscopic examination, given by means of spinal anesthesia, revealed a bladder capacity of 30 cubic centimeters and diffuse inflammation of bladder mucosa; pyelograms showed hydronephrosis and hydro-ureter, grade 2. A presacral neurectomy was performed. Immediately after operation there was no spasmodic pain; the patient voided every 30 to 60 minutes, with burning in the urethra; and the amounts varied from 30 to 100 cubic centimeters. Two months after the operation the patient voided about 50 to 100 cubic centimeters every hour, with slight burning. There was occasional slight incontinence. A second cystoscopic examination, given by local anesthesia, showed the following: bladder mucosa normal throughout; normal sensations in bladder; pain on overdistention of the bladder; and infection greatly reduced. Ten months postoperatively there was no bladder pain; voids up to 150 cubic centimeters every 1 to 2 hours, with only slight urethral burning. The cystoscope used by means of local anesthesia at that time revealed a normal mucosa; normal bladder sensations, pain on overdistention of the bladder and a very slight amount of infection.

The patient has experienced some improvement in frequency and bladder capacity, and complete relief from the intolerable paroxysms of spasmodic pain which had incapacitated her. She is entirely satisfied with the improvement of her status and has used no morphine since her operation.

CASE 2. J. G., No. 393961, a male farmer, aged 25 years, had Hunner ulcers of the bladder with moderate intractable bacillary infection of the bladder for 8 years which was resistant to all forms of therapy. There was no prostatic infection. The symptoms were: frequency of urination every 1 to 2 hours by day, and 4 or 5 times during the night; burning on urination; pain when bladder filled; severe spasmodic pain on urination; and voids amounting to from 90 to 150 cubic centimeters. Cystoscopic examina-

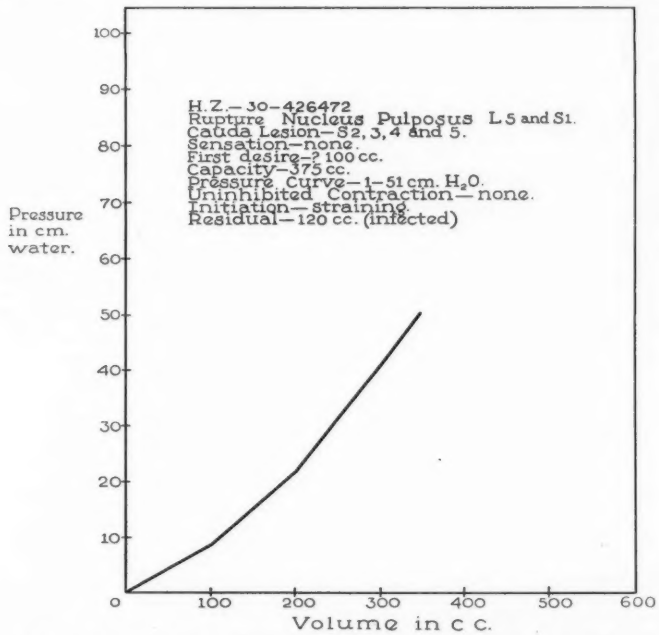


Chart 1. The autonomous neurogenic bladder. Rupture nucleus pulposus April, 1938, with pain in back and saddle anesthesia. June, 1938, developed practically total urinary retention with slight overflow incontinence; catheterized intermittently. There was bowel incontinence. Patient seen in University Hospital on July 11, 1938, with neurological findings of lesion of second, third, fourth, and fifth sacral cord segments with sensory loss only. Cystometric study July 11, 1938, demonstrated autonomous neurogenic bladder. Laminectomy and excision of ruptured intervertebral discs of fifth lumbar and first sacral on July 19, 1938. Cystometric studies August 1, August 16, and September 27, 1938, show autonomous bladder. Patient voids only with straining, overflow incontinence at night, controlled by Credé every 2 hours during the day. Sensations of heat, cold, tactile, and electric stimulation are absent; first desire and filling diminished or absent. Ejaculation, erection, and tonus of internal vesical sphincter are preserved. There is no pain on inducing bladder spasm.

tion, made with spinal anesthesia, showed a bladder capacity of 150 cubic centimeters, several typical Hunner ulcer lesions in the bladder, and hemorrhage on overdistention. Pyelograms revealed the right side to be normal and on the left side a slight hydronephrosis. A presacral neurectomy and exeresis of the lateral sacral sympathetics were performed. Immediately after the operation there was urinary retention with severe pain. This was relieved by an indwelling catheter drainage for 10 days followed by frequency every 15 to 30 minutes with severe burning in the urethra which subsided in 1 week. The patient was discharged on the forty-second day, voiding amounts from 100 to 150 cubic centimeters with complete comfort. Four months later voids continued to amount to 100 to 150 cubic centimeters with complete comfort. There was slight bladder pain on overdistention but urine was normal. Cystoscopic examination still showed active lesions of the Hunner ulcers, but there were normal sensations throughout the bladder to various stimuli. Ten months after operation he voided normally, without pain, and output amounted to 150 to 175 cubic centimeters. The patient wrote: "Am riding tractor every day and am grateful to be relieved of those awful spasms I used to have."

Case 3. A. S., No. 413118, a housewife, 34 years of age, had Hunner ulcers of the bladder, chronic pyelonephritis with mixed infection which was resistant to all forms of therapy. This condition had existed for 3 years. The symptoms were: frequency every hour, day and night; dull aching pain on bladder distention, severe paroxysms of spasmodic pain on urination, and voids of 60 to 90 cubic centimeters. The cystoscopic examination, made with spinal anesthesia, revealed a bladder capacity of 90 cubic centimeters, diffuse inflammation of the bladder mucosa, and several typical Hunner ulcers which bled on overdistention of the bladder. Pyelograms showed typical changes of chronic pyelonephritis with clubbing of calyces and definite narrowing of the infundibula. A presacral neurectomy and exeresis of the lateral sacral sympathetics

were performed. The patient voided normally without incontinence immediately after the operation and was free from bladder spasm or pain. Voids amounted to 100 and 150 cubic centimeters. She was discharged on the seventeenth postoperative day. Four months later the patient voided up to 150 cubic centimeters once an hour during the day and 4 or 5 times during the night. There was no spasmodic pain on urination and no incontinence, but she had mild dull pain in bladder on distention. A cystoscopic examination with local anesthesia revealed the Hunner ulcers to be unchanged. Eleven months after operation the patient had been free from severe pain; there was some bladder discomfort consisting of dull burning pain when bladder was distended or when she was fatigued. Frequency of urination without incontinence, was each hour by day and 3 to 5 times during the night; voided 30 to 120 cubic centimeters. The patient stated that her bladder capacity was clearly limited by the discomfort of distention. The cystoscope revealed the Hunner ulcers to be unchanged, severe pain on distention of the bladder, but normal sensations throughout the bladder to various stimuli.

With this patient there was complete relief from severe spasmodic pain, no improvement in frequency or discomfort on distention of bladder, slight increase in bladder capacity, and no change or improvement in Hunner ulcers; but she was completely satisfied and grateful for her operative result.

CASE 4. B. B., No. 413888, a housewife, 26 years of age, had Hunner ulcers of the bladder with moderate intractable staphylococcal infection of both kidneys, resisting all forms of therapy, for 1 year. Urination had occurred every 15 to 30 minutes for 3 to 4 months. The patient slept on a bed pan and had intolerable bladder spasms on moving about and on urination. Spinal anesthesia was administered for the cystoscopic examination which revealed a bladder capacity of 60 cubic centimeters and a bladder highly inflamed throughout with several areas of ulceration. The pyelograms showed bilateral hydronephrosis and a one plus hydroureter. A presacral neurectomy with exeresis of the lateral sacral sympathetic chains was performed. Immediately after the operation the patient voided normally, without any discomfort, amounts ranging from 50 to 60 cubic centimeters for the first week. The capacity for the second week increased from 150 to 300 cubic centimeters with freedom from pain. She was discharged on the twenty-first day voiding from 180 to 200 cubic centimeters without discomfort. Two months later she voided from 100 to 250 cubic centimeters with complete absence of bladder spasm but had slight burning in the urethra and had pain on overdistention of the bladder. A cystoscopic examination, made with local anesthesia, showed 3 typical Hunner ulcer lesions in the bladder, but urine was normal. Eleven months after operation she voided every 2 or 3 hours with slight terminal burning in the urethra; she had no spasm and no pain in the bladder. She had slight urinary incontinence at times with loss of a few drops of urine and wore a napkin to prevent soiling her clothes. A cystoscopic examination revealed a bladder capacity of 180 cubic centimeters; overdistention produced severe pain, the bladder was normal throughout except for the Hunner ulcer areas which showed no change; bladder sensations were entirely normal.

With this case there was improvement but no cure of frequency; there was complete relief of spasmodic pain which incapacitated the patient. She still had Hunner ulcers and had acquired a slight urinary incontinence, but was completely satisfied with the operative result.

CASE 5. M. S., No. 399155, a housewife, 25 years of age, had tuberculous cystitis persisting for 1 year without relief, following nephrectomy for renal tuberculosis. The symptoms were: frequent urination, every 30 to 60 minutes by day and 5 to 8 times at night with burning and severe bladder spasms and pain on each urination. General anesthesia was administered for the cystoscopic examination which revealed a diffusely inflamed bladder, a bladder capacity of 75 cubic centimeters, left kidney urine normal, pyelogram normal, but bladder urine contained pus and tubercle bacilli. A presacral sympathectomy and lateral sacral sympathetics exeresis were performed. Immediately there was the normal desire to void and complete continence with no pain. By the tenth postoperative day the patient was voiding 100 to 150 cubic centimeters. She was discharged on the sixteenth day having no pain but moderate urethral burning on urination. During the night she voided about 1 or 2 times. Three months later she returned for a check up. She had been asymptomatic till a few days before when she developed increased frequency and urethral burning but no pain. The urine was found to contain many Bacillus coli. The patient was given a course of sulfanilamide with a regression of the frequency. Four months after operation the patient reported that she had continued free from her symptoms.

This patient had been relieved materially of her urinary frequency. Her capacity had considerably increased and she had remained entirely free from her spasmodic bladder pain.

CASE 6. C. W., No. 374641, male, a 41 year old laborer, had tuberculous cystitis for 2 years following nephrectomy for right renal tuberculosis. He had had bladder irritation for 7 years prior to nephrectomy. He had a frequency of 1 to 2 hours during the day and night with spasms of pain on urination. Tubercle bacilli were found in the urine. Cystoscopic examination was made with general anesthesia revealing a diffuse ulcerative cystitis and a bladder capacity of 110 cubic centimeters. A presacral neurectomy was performed. Immediately afterwards he voided normally without incontinence. Frequency and capacity remained unchanged over pre-operative state. There was no pain on urination. Four months later there was no increase in bladder capacity or frequency, patient voiding with complete absence of bladder pain or spasms, but there was some burning in the urethra. Seven months after operation his general condition was excellent. He was continent, his urine was 4 plus pus and tubercle bacilli, and he voided every 2 hours day and night with complete comfort.

This patient had not been relieved of his urinary frequency but has been made completely comfortable.

Analysis of these cases reveals certain constant factors. Prior to operation all had severe spasmodic bladder pain; all had some degree of difficulty in voiding although none had residual urine; all patients required general anesthesia for cystoscopic examination; and cystometric examinations in all instances revealed definite hypertonicity of the detrussor mechanism.

Following operation all patients were completely relieved of bladder spasm with its associated excruciating pain. In no instance has this spasmodic pain returned. All patients voided with ease following operation and 1 of the 4 female patients had slight urinary incontinence. Postoperative cystoscopic examinations were made in all cases under local anesthesia. All patients showed some residual bladder lesion and complained of pain on forcible distention of the bladder. Whether or not vascular spasm existed prior to operation and was relieved by it, was not discernible in this series. All patients showed an increase in bladder capacity immediately following operation. This increase in bladder capacity had persisted in 2 patients, while in 4 it had reverted toward the pre-operative level. None of these patients had been relieved of abnormal urinary frequency. None of the 3 patients with Hunner ulcers showed improvement of that lesion or relief from the discomfort usually associated with bladder distention in that disease.

All of the patients here reported are satisfied and grateful for the relief of their intolerable pain in spite of the fact that none can be considered as cured by the operation.

SUMMARY AND CONCLUSION

From the facts here presented it seems evident that sympathectomy relieves bladder pain, not by removing the essential afferent pathways from that viscus but by relieving spasm of the internal sphincter and perhaps other parts of the bladder musculature. Certainly the one constant and predominating feature of all the cases of this series was vesical spasm prior to operation. Likewise the one constant postoperative result was relief from intolerable spasm and ease of urination. These observations and conclusions completely bear out those of Douglas and the theories expressed by others.

It further appears evident that sectioning of the hypogastric nerves alone, without the more extensive and hazardous division of the lateral sacral sympathetics provides adequate relaxation of the sphincter to relieve bladder spasm.

Since normal afferent components exist in the bladder following sympathectomy, it appears illogical to suppose that bladder pain resulting from malignancy should be relieved by this operation.

In conclusion we would repeat:

1. The parasympathetic (sacral) pathways carry the essential afferent components of the bladder.

2. The sympathetic (presacral, or hypogastric nerves) pathways may or may not carry afferent pain components of the bladder.

3. Division of the presacral nerves provides relief of vesical spasm and pain resulting from intractable bladder infections.

4. Division of the lateral sacral sympathetics in addition to the presacral nerves accomplishes this same end but does not appear to be necessary or desirable.

5. Sympathectomy brings about the relief of spasmodic pain by relaxation of the vesical outlet and the detrussor mechanism; it does not render the bladder insensitive to pain of other origin.

6. Sympathectomy for the relief of bladder pain should be resorted to in only those patients in whom that pain is clearly demonstrated to result from spasm of the vesical outlet.

7. Sympathectomy was not shown to cure the lesions of Hunner ulcer in the cases here reported.

BIBLIOGRAPHY

1. Braasch, W. F. Spastic irritable bladder controlled by sympathectomy. Proc. Staff Meet. Mayo Clin., 1934, 393, 9: 27.
2. Chauvin, E. Resection of presacral nerve in rebellious cystitis. J. Urol., 1930, 30: 201.
3. Cheetham, J. C. Presacral neurectomy for relief of certain types of bladder dysfunction and pain. J. Urol., 1937, 148, 37: 1.
4. Idem. Presacral nerve resection for relief of bladder dysfunction and pain. West. J. Surg., 1938, 45: 260-266.
5. Cotte, G. Resection du sympatheque pelvieu. Gynec. et. obst., 1931, 23: 233.
6. Idem. Resection du nerf presacre pour dysmenorrhea et cystalgia. Lyon Chir., 1932, 29: 616.
7. Craig, W. M. Discussion of presentation by Braasch, W. F. Proc. Staff Meet. Mayo Clin., 1934, 396, 9: 27.
8. Cumming, R. E., and Schroeder, C. F. The neurosurgical treatment of bladder pain. To appear in early issue of J. Am. M. Ass., 1939.
9. Davis, A. A. The surgical anatomy of the presacral nerve. J. Obst. & Gynæc. Brit. Emp., 1934, 41: 942–952.
10. Idem. The presacral nerve—its anatomy, physiology, pathology, and surgery. Brit. M. J., 1934, 2: 1.
11. Denny-Brown, D. E. Nervous disturbances of the vesical sphincter. New England J. Med., 1936, 215, 15: 647–664.
12. Douglas, H. L. Excision of the superior hypogastric plexus in intractable cystitis; report of 5 cases. Am. J. Surg., 1934, 25: 249–253.
13. Idem. Indications for excision of the superior hypogastric plexus in disfunction of the bladder. South. Surgeon, 1934, 3: 148–156.
14. Elaut, L. The surgical anatomy of the so called presacral nerve. Surg., Gynec. & Obst., 1932, 55: 581–589.
15. Fulcher, O. H. Presacral neurectomy for certain vesical conditions. West Virginia M. J., Wheeling, 1935, 31: 465.
16. Grant, F. C. The surgery of the autonomic system of the urinary tract. J. Urol., 1936, 36: 261.
17. Gruber, C. M. The autonomic innervation of the genito-urinary system. Phys. Rev., 1933, 13: 497.

18. JABOULARY, M. Le traitement de la névralgie pelvienne, etc. Lyon méd., 1899, 90: 102.
19. LATARJET, A., and BONNET, P. Le plexus hypogastrique chez l'homme. Lyon. chir., 1913, 9: 611.
20. LEARMONTH, J. R. A contribution to the neurophysiology of the urinary bladder in man. Brain, 1931, 54: 147.
21. Idem. Neurosurgery in the treatment of diseases of the urinary bladder. J. Urol., 1931, 26: 13.
22. Idem. The value of neurosurgery in certain vesical conditions. J. Am. M. Ass., 1932, 98: 632.
23. LEARMONTH, J. R., and BRAASCH, W. F. Resection of presacral nerve in diseases of the bladder. Tr. Am. Ass. Genito-Urin. Surg., 1932, 25: 313.
24. MCCONNELL, A. A. Vesical pain. Irish J. M. Sc., 1933, 85: 209–211.
25. MCCREA, E. D., and MACDONALD, A. D. Presacral sympathectomy and the urinary bladder. Brit. J. Surg., 1934, 6: 119–127.
26. PEARL, F. L., and STRAUSS, B. Presacral neurectomy and sacral ganglionectomy in affections of the bladder. J. Urol., 1938, 39, 5: 645.
27. PIERE, G. Enervation ou ramisection. Presse méd., 1926, 34: 1141.
28. Idem. Contributi clinicii. Arch. ital. di chir., 1930, 27: 454.
29. QUINBY W. G. Resection of presacral nerve in painful bladder of interstitial cystitis. Tr. Am. Ass. Genito-Urin. Surg., 1931, 24: 355.
30. RIDDOCK, G. Conduction of sensory impulses from the bladder by the inferior hypogastrics. J. Physiol., 1921, Liv., 134; in Proc. of the Physiol. Soc., of Feb. 12, 1921.
31. ROCHET, V. Traitement chirurgical des cystitis douloureuses. Lyon chir., 1921, 18: 462.
32. SCOTT, W. J. MERLE, and SCHROEDER, CARLISLE F. Denervation of the bladder for relief of intractable pain. Ann. Surg., 1938, 108: 730–741.

OBSTRUCTIVE UROPATHIES

ALEXANDER RANDALL, M.D., F.A.C.S., and P. BOLAND HUGHES, M.D.,
Philadelphia, Pennsylvania

IN 1926 the term, obstructive uropathy, was introduced into medicine by Young with the following definition: "Under this heading are grouped all the changes in the kidney, pelvis, ureter, bladder, and urethra resulting from obstruction to the free outflow of urine from the urinary tract." This definition epitomizes the urological interpretation of disease prior to the introduction of intravenous urography, when we thought only in terms of organpathology and organphysiology. We were by then becoming familiar with the usual gross lesions of the urinary organs and, as is always the case, we were striving for a similar familiarity with the evidences of earlier pathological changes. But we still thought in terms of individual organpathology.

Since the advent of intravenous urography in 1930 we have learned to evaluate all urinary tract disease, except renal neoplasms, in terms of urinary tract function rather than in terms of the pathological end-picture; and for the first time we have been able to visualize competently the normal and the perverted physiological function, and to picture and study the entire urinary system uninfluenced by any extraneous artifact. We should, therefore, revise our previous conception of an obstructive uropathy by realizing that we are not interested so much in the *static changes* in the urinary organs "resulting from obstruction to the free outflow of urine," as in the *vital changes*—changes in urinary tract function—which can be determined only through a physiological interpretation of the intravenous urogram. If urinary tract function has been affected by our obstructive uropathy, we must differentiate between a derangement due principally to impaired renal function, and a derangement due to deficient urinary transportation. These two factors, though interdependent, must be distinctly separated and individually analyzed.

In this paper we will confine ourselves entirely to the upper urinary tract. A brief consideration of the dynamics of the upper urinary tract will serve as an introduction.

When an obstructing lesion produces disturbance of urinary tract function, resulting dilatation of the urinary tract is just an anatomical compensating factor. Important, however, is the kinetic, or emptying factor. Renal function and urine transportation will not be impaired in these cases of dilatation if the kinetic function maintains a normal emptying rate. Any sudden mechanical obstruction, such as the impaction of a small stone in the ureter, results immediately in pelvic and ureteral hypertony and hyperkinesis, i.e., a renal colic. In any chronic, partial obstruc-

From the Department of Urology, Hospital of the University of Pennsylvania.

Presented in the Symposium on Urological Infections, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

tion there first occurs hypotony and hyperkinesis. With the continuation of a chronic, partial obstruction this compensating stage of urinary tract function passes shortly into the decompensating stage of hypotony with hypokinesis, which may finally end in complete atony. These stages may be diagnosed by intravenous urography.

So much for the dynamics of urinary transportation. What about renal function? In acute, complete obstruction, in which the urinary tract is hypertonic and hyperkinetic, there may be a reflex cessation of renal function. In these cases all our diagnostic functional methods would reveal no renal function; yet, if such obstruction be of short duration, renal function returns to normal. In chronic, long standing, partial obstructions, in which the urinary tract is in the decompensating stage of hypotony and hypokinesis, renal function is impaired; but no test has yet been devised to tell us the degree of permanent impairment. All functional tests merely measure renal function at the time the test is done. However, we know clinically how many times supposedly functionless kidneys have shown permanent improvement of function, sometimes to a very great degree, when the obstruction has been removed. We believe that there will always be some restoration of renal function if the renal parenchyma has not been entirely destroyed, provided there is not complete atony of the urinary tract. This can be determined by the response of the pelvis and ureter to faradic or other stimulation at the time of operation.

From the standpoint of renal function it is important to know whether the renal pelvis is intraparenchymal or extraparenchymal, for intraparenchymal dilatation will cause much greater pressure death of functioning renal tissue than if it is possible for the pelvis to dilate extraparenchymally. We will discuss later the rôle such intraparenchymal pelvic dilatation might play in hypertension. However, the extent to which an obstructive uropathy may be evaluated in terms of impaired urinary tract function depends upon an inherent system reserve, the factors of which are primarily: (1) The ability of the kinetic factor to maintain normal emptying rate in hypotonic dilatation of the urinary tract; (2) the ability of kinetic recovery in cases of hypotony and hypokinesis after the mechanical obstruction is removed, or after the cause of an adynamic obstruction (infection) is eliminated; and (3) the ability of the renal pelvis to dilate extraparenchymally, in which case pressure destruction of the renal parenchyma will be minimized.

All are familiar with the various pathological processes which may cause obstruction in the upper urinary tract. If we consider the etiology of obstructive uropathies, we may classify all these processes into 2 main groups: The first group is that of *mechanical obstructions*, which is further subdivided into the intrinsic obstructions, such as stone, congenital stricture, etc., and the extrinsic obstructions, such as periureteritis, accessory blood vessels, ureteral kink, renal ptosis, etc. The second main group we have called the *adynamic obstructions*, which include congenital atonies, infectious atonies, usually due to lymphatic extension of infection from the adnexa, and idiopathic neuromuscular dysfunction.

The symptomatology of obstructive uropathy is indefinite. In the adynamic obstructions pain never occurs. In the mechanical obstructions typical colic-like pain occurs only if the renal pelvis or the ureter be suddenly distended. In the gradually acquired pathological states, however, there seems to be a decided tendency for sensory symptoms to be referred to the gastrointestinal tract, and to be given naturally a gastrointestinal interpretation.

Much could be written concerning the rôle of infection in obstructive uropathy. Extension of an infection from the adnexa through the periureteral lymphatics may produce an adynamic disturbance of urinary transportation. Infection within the urinary tract itself always hastens renal destruction. Most important, however, is that the persistence of infection is almost proof of existing obstruction to the free transportation of urine, whether this obstruction be of the mechanical or of the adynamic type. It is almost impossible to infect experimentally a normal urinary tract. Conversely, it is almost impossible to disinfect a poorly emptying urinary tract. One of our therapeutic axioms states that a urinary infection cannot be eradicated in cases of urinary stasis, even if renal function allows sufficient concentration of our urinary antiseptic at the site of the infection.

In closing, let us see what relation obstructive uropathy might have to hypertension. Goldblatt and his co-workers have shown that experimental hypertension in dogs may be produced by partially constricting one renal artery. Leadbetter and Burkland have recently reported a case of hypertension in a boy 5½ years of age, which was cured by removing a functionless kidney, the main artery of which was found to be almost completely occluded by a smooth muscle plug which reduced the lumen to a mere crescentic slit. Butler records 2 cases of hypertension associated

with unilateral pyelonephritis in children whose blood pressure returned to normal after nephrectomy. Arteriolar changes were found in the removed kidneys. Freeman and Hartley have recently added another interesting case of hypertension associated with renal ischemia. We recently obtained a similar clinical result by removing a hypoplastic kidney with hypoplastic renal vessels from a young man 28 years of age. There is clinical evidence, therefore, that renal ischemia in one kidney may produce hypertension in man just as it does experimentally in dogs.

But renal ischemia does not necessarily have to be caused by partial constriction of the renal artery. Hartwich, and Harrison and his co-workers have produced hypertension in dogs by ligation of one or both ureters. In man, however, hypotension is just as frequently associated with ureteral occlusion as hypertension. The renal pelvis in dogs is principally intraparenchymal, and dilatation can readily cause renal ischemia by parenchymal pressure. In man, due to the anatomical relationship of the pelvis to the parenchyma, dilatation is frequently almost entirely extraparenchymal. In these cases, of course, ureteral occlusion would not be as liable to produce renal ischemia. What percentage of cases of hypertension in obstructive uropathy can be explained by a dilating intraparenchymal pelvis remains to be determined by further clinical investigation.

In conclusion, it may be stated that the rôle of obstructive uropathy broadens as we begin to appreciate and to interpret the finer and earlier diagnostic criteria, and to correlate with this study a growing appreciation of the normal and the perverted physiology of urine transportation. The value of intravenous urography is without parallel and is indispensable in attaining this end.

BIBLIOGRAPHY

1. Butler, A. M. Chronic pyelonephritis and arterial hypertension. J. Clin. Invest., 1937, 16: 889.
2. Freeman, G., and Hartley, G., Jr. Hypertension in a patient with a solitary ischemic kidney. J. Am. M. Ass., 1938, 111: 1159.
3. Goldblatt, H., Lynch, J., Hanzal, R., and Summerville, W. Studies on experimental hypertension. J. Exper. Med., 1934, 59: 347.
4. Harrison, T., Mason, M., Resnik, H., and Rainey, J. Changes in blood pressure in relation to experimental renal insufficiency. Tr. Ass. Am. Physicians, 1936, 51: 280.
5. Hartwich, A. Die Beziehungen zwischen Niere und Blutdruck im Tierexperiment. Verhandl. d. deutsch. Gesellsch. f. innere Med., 1929, 41: 187.
6. Leadbetter, W. F., and Burkland, C. E. Hypertension in unilateral renal disease. J. Urol., 1938, 39: 611.

SYMPOSIUM: TREATMENT OF FRACTURES

CONSERVATIVE TREATMENT OF FRACTURES

E. L. ELIASON, M.D., Sc.D., F.A.C.S., Philadelphia, Pennsylvania

EXAMINATION of the records of several local hospitals shows that from 10 to 15 per cent of patient visits are made for fracture treatment. Such a common condition probably exists uniformly in other communities and must of necessity be met and treated by a great number of physicians, not all surgeons by any means.

Fractures are, however, the pet aversion not only of the general practitioner but of many surgeons. The reason is twofold: The average physician will not take the time to equip himself with a thorough knowledge of fractures nor will he exercise the patience and the painstaking, time-consuming care necessary for a favorable outcome. Consequently the ultimate results in broken bones are not all that could be expected nor that we could desire. The same discontent is experienced by the patient and hence the frequency of suits for malpractice which is the second reason for the unpopularity of fracture cases in the eyes of the physician.

This dislike of fractures is made even greater by reason of the fact that we have run wild with invention and production of costly, strange, wondrous, and complicated gadgets with a multiplicity of levers, nuts, screws, weights, springs, etc., designed to fit fracture treatment into the machine age. Many of these puzzling contraptions are expensive and most of them are cumbersome and require a mechanic or engineer to assemble them. Our hospital storage spaces contain hundreds of dollars worth, bought for one surgeon, for one patient, employed once, often unsuccessfully, and discarded thereafter. In the hands of the originator a complicated apparatus may work wonders, but may cause only confusion and defeat in another. The man and not the splint is responsible for the result. Hippocrates said that the man who presumes to treat fractures must be equipped to do so under any conditions. Special splints for special fractures are desirable and often necessary, yet the simpler methods of reduction and fixation that have stood the test of time will in the long run, in the greatest number of hands, in the greatest number of patients, produce the greatest number of good results.

Information on fracture treatment should, therefore, be conservative and simple enough in its application to be useful to the general practitioner, reserving the more complicated methods for the unusually difficult cases in the hands of men trained for such work.

Most of the principles of fracture treatment have come down to us from the centuries and a brief historical paragraph may be of interest. Magnuson, of Chicago, wrote a most interesting historical article upon this subject and I will not hesitate to quote some of his facts. Records of fracture treatment come to us from 4,500 years ago. Braestead and Smith, after examining about 5,000 mummies, found that about 5 per cent had fractures, many with splints in place. These fractures had been treated logically and gave excellent results even under our standards of today. Principles enumerated 2,500 years ago are sound today. These ancients spoke of "traction and counter traction, position of muscle balance, alinement regulated according to nature, early reduction, traction in the long axis, prevention of pressure points, elevation for swelling, and suiting the splint to the patient and not the reverse." Warning was given not to remove splints until union was solid and designation was made of the average time required for union in the various fractures. This knowledge was carried to Rome by the Greeks and in the first century A.D. Martial referred to Hermes as the best surgeon for fractures and remarked that there were many specialists, some for enlarged tonsils, some cutters for stones, some bone setters, blood letters, and some for removing brands from slaves.

Old as these tenets are, have we respected them as we should? Do we remember and practise them? Do we make use of our x-ray always as a blessing or do we make it into a curse and treat the film evidence rather than the broken bone in the patient? Has simplicity been replaced with

From Section "A" of the Surgical Clinic of the Hospital of the University of Pennsylvania.

Presented in the Symposium on Fractures, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

complexity and multiplicity and the desire to do open reduction for a cabinet-maker's reposition? And have we forgotten that the aim of all fracture treatment is the restoration of function with or without restoration of contour? Reported figures show that only 65 to 66 per cent of fractures with good reposition gave good function whereas 45 per cent with poor reposition gave good function. Evidently factors other than the position of the fragments are concerned. It is better to have a deformity with function than a perfect union with dysfunction that results in a reduction of the individual's earning power. The patient must have at least the function necessary for his livelihood.

The 4 factors of most importance in the treatment of any and all fractures are promptness, gentleness, thoroughness, and individuality, as stated by Dr. William Darrach many years ago.

Promptness. No patient suffering with a fracture of a long bone shaft should be moved until the best available fixation has been applied. The trauma of injudicious first aid treatment is often responsible for the bad results. Such careless and injudicious treatment is not always limited to the aid given by the laity, but is all too often met with after the patient reaches the hospital. A patient with a fracture of the shaft of a long bone transported without adequate splinting will have added vessel, muscle, and nerve injury. The limb should be placed as nearly as possible in the position of muscle equilibrium. In the case of the lower extremity, traction as nearly as possible in the direction of the long axis of the uncontrollable fragment is really a necessity. In the humerus, the weight of the limb slung at the wrist together with chest binder will suffice if the patient is transported in the upright position. In fact, actual lengthening of the part is sometimes thus obtained. Needless to say, if shock exists, the appropriate treatment together with morphia should be instituted. Figures indicate that proper transportation splinting, together with large doses of morphia, reduced the mortality in compound fractures of the femur in the World War from 75 to 15 per cent.

The actual or definite treatment of the fracture should be undertaken just as soon as possible, the condition of the patient permitting. A very careful examination should be made with reference to possible visceral, nerve, or vascular injury before any manipulation is attempted. The original trauma causes nerve injuries quite often in certain fractures, 4 to 8 per cent in cases of fracture of the humerus; of 211 nerve injuries with fractures quoted by Lewis and Miller, 24 per cent were primary and 42 per cent secondary and incident to treatment. Such knowledge should serve to indicate the need for observation and prevention. Should such injuries be found, the patient or members of his family should be informed of their serious nature. The earlier the reduction is attempted the easier its accomplishment. A properly reduced fracture becomes increasingly more comfortable. Persisting pain requires investigation.

It has been the writer's privilege to be present on the field and see many fractures occur in athletic pursuits. Immediate gentle traction and manipulation within a few seconds while the tissues were numb and the muscles relaxed, resulted in a very high percentage of reductions sufficiently perfect as to require no further adjustment. Delay permits coagulation, fibrin formation, and cellular exudation with consequent loss of tissue elasticity. The blood at the fracture site soon loses its liquid state and becomes a fibrinous, gum-like, clotted mass, interfering with bone reposition and making it more difficult or even impossible. Such are the effects of delay. It is only fair to state that there are some who advocate delay for varying periods of time (days) before reduction is attempted. These advocates report good results. Adequate assistants, satisfactory anesthesia, local, spinal, or ether, and, when possible, the fluoroscope, are very desirable. It may be stated here that in acute fractures only a few hours old, novocain injected around the fractured surfaces is most satisfactory in preventing pain and producing muscle relaxation during the reduction. Furthermore, the patient being conscious very often can cooperate splendidly.

Today as soon as a fracture patient is admitted to the University of Pennsylvania Hospital, the interne on service examines him thoroughly for associated injuries, meanwhile notifying the chief or his assistant on service, and they and the patient meet in the fluoroscopic room where the reduction is conducted. The interne is active in the reduction, being aided and supervised by his seniors. Only when he fails does the more experienced man take hold. This practice has increased the number of successful primary reductions from 45 to 80 per cent in a few years.

Gentleness. No fracture should be traumatized any more than necessary. Eliciting of crepitus is not necessary for diagnosis. It may be harmful. All movements affecting the fractured bone should be undertaken slowly and gently, gradually increasing traction in the direction of muscle equilibrium or balance. If care is exercised in obtaining this position of muscle equilibrium, not only will the reduction be simple, but there will be a mini-

mum amount of trauma incident to the reduction. We are taught that certain muscles act to produce certain physiological movements and positions of parts. Additional observation under the fluoroscope, together with the aid of a conscious patient and local anesthesia, aids greatly in determining the full extent of these muscular actions. A fracture of the shaft of the forearm bones is the best example of this. Experience has shown that here the best position for reduction is with the elbow acutely flexed, and the forearm acutely supinated with traction exerted from over the shoulder of the affected side.

Trauma means destruction and increased hemorrhage, devitalization, and added difficulty due to muscle spasm and pain. Many times roughness has defeated the purpose.

Thoroughness. If success is to be our reward, thoroughness is essential and yet it must not be overemphasized. A cabinet-maker's or perfect reduction does not insure a perfect function nor does the absence of perfect reduction necessarily indicate diminished function. It is here that individuality and judgment play such an important rôle. In the past there were only two parties concerned in a fracture result, the patient and the surgeon. A fair anatomical result, with fair or good function, satisfied both. When the roentgen-ray entered the field at once there was born the desire to obtain the so called roentgen or a cabinet-maker's reduction. This resulted in an associated increase in the number of open reductions. Next, a third party entered the field, namely, the insurance companies and our results are now scrutinized by this third party with an impartial eye.

In some respects this has been advantageous to the patient but in other respects it has led to the desire to obtain the so called perfect reduction. Why? It is due to the fact that a jury is more than likely to judge the result by the roentgenographic evidence and not by the degree of function obtained. Hence, we actually find that more open reductions are resorted to in an endeavor to meet this demand. Then, too, if the patient or his family view the film, which should always be insisted upon, they ask for open reduction thinking it necessary for a good result.

Individuality. Life, limb, and function for each individual is necessary. Restoration of contour is desirable if compatible with these. A fracture is not only a broken bone but injured soft parts in addition. In fact the soft tissue damage, separately and collectively, may be, and often is, more important at the time of the accident and later when considered in the light of functional results. Perfect alinement, perfect reduction, minimum deformity, etc., are desirable but not always necessary for restoration of function. It must be the aim of the surgeon to evaluate the numerous factors with relation to required results for the individual case and so conduct treatment. So varied may be the injuries associated with a broken bone, so numerous the constitutional factors incident to age, disease, site of fracture, function desired, economic conditions, etc., required for each particular case, that individuality rather than generality in treatment must obtain. Principles are comprehensive and abstract, but practice must be individual and concrete. Each patient and treatment must click. Fit the treatment to the patient and not the patient to the treatment.

A young person will obtain a better result than will an adult with the same original deformity, by reason of growth factors. A young tennis player will require better function in his forearm than will the retired banker of 70 years. A bad cardiac case might rather have malunion than an open reduction. A badly comminuted fracture of the femur merely requires length and alinement, not perfect reposition. An athlete will require length and alinement for a fracture of his leg. An elderly night watchman could put up with a limp. It is astonishing what vicious deformities may accompany excellent functional results in fractures in the upper extremity of the humerus for example when treated conservatively. Epiphyseal separations do not often require perfect reposition at the expense of an open reduction. Again our statistics show that open reduction in these latter cases is necessary in less than 3 per cent.

A surgeon treating fractures must be practical and must have a mechanical sense. He must be willing individually to at least supervise the treatment throughout the case. Treatment should be absolutely, entirely, and constantly under the guidance of one man.

The initial attempt at a reduction should be accompanied by every factor that could be desired to insure success, proper and sufficient assistance, complete relaxation anesthesia, fluoroscopic control, and the necessary armamentarium for traction and fixation as required. Repeated attempts at reduction militate against the best results, often terminating in open reduction. Our statistics show this relationship very definitely. At certain sites such repeated trauma may terminate in non-union. Ashhurst stated years ago that malunion of moderate degree is less evil than non-union.

When may accurate reduction be imperative? Although not always necessary the best restoration of contour may be required in fractures near or into a joint, in the mid shaft of the humerus,

and in the forearm. Length and alinement is very essential in all lower limb fractures.

Open reduction. Open reduction may be fraught with great danger of loss of function, limb, or even life. To teach the promiscuous employment of this method will bring sorrow to many in its application. This refinement should be resorted to only after much deliberation. If experience has shown that the type of fracture under consideration will heal with good function despite its displacement, let sleeping dogs lie and treat the fracture by the closed method.

There are 3 indications for open reduction in an acute fracture, namely, failure to obtain a satisfactory reduction by the closed method, failure to maintain a satisfactory reduction, and lastly, and probably the most important, the surgeon's ability to obtain a satisfactory result if he resorts to an open reduction. In order to have a clear understanding we must explain what the term, satisfactory, should mean in each of the 3 instances. Here, again, individuality enters the field.

The assurance of a satisfactory result, if open reduction is to be undertaken, is almost imperative. We must base this assurance on the experience we have had in fracture surgery, the bone or bones involved, and the level of the fractures in the same, the condition of the patient's health, his age, the age of the fracture, and whether our efforts can accomplish a better functional, not necessarily a better anatomical result. Extensive comminution as a rule should be a deterrent to open reduction.

It is not the purpose of the writer to discuss the surgical technique of open reduction but I would like to emphasize one point. Throughout the literature on the subject, emphasis is placed on keeping the gloved hands out of the wound. Too much emphasis upon this detail has hampered many an operator to the detriment of the patient. In reality there seems to be no reason why a fresh glove, previously untouched, should enter the wound with any more danger than an instrument. The gloved finger inserted at the fracture site will inform the surgeon at once concerning the character and condition of the fractured area and the direction for extension of the incision if desirable, and hence minimize the trauma that must of necessity follow, due to tissue injury by needlessly large misplaced incisions and retractions required to permit visualization.

Here a word may well be added with regard to internal fixation in open reductions in general. It has been the writer's practice in the past to use internal fixation (plate and screws preferably) only when the fragments will not remain in their proper relationship with the limb placed in the muscle balanced position. Adherence to this principle is responsible for the need for internal fixation in only 18.3 per cent of cases in which patients have been operated upon.

The age of the fracture in poor position or with vicious union needs individual judgment; neither, invariably will mean poor function. To attempt to break up a vicious position with 2½ inch shortening in a 14 weeks' old fracture may be justified in a youngster but not in a hemiplegic or a patient with Buerger's disease.

Roentgenograms. Films showing 2 views should, when feasible, be taken of every suspected fracture before an attempt is made to reduce it. This both lessens the possibility of trauma and protects the surgeon against the accusation of injury influenced by his manipulation. After the reduction of a fracture under an anesthetic the roentgenogram should not be taken until the anesthetic has ceased to act. Many times a fracture will remain reduced with the muscles still under the anesthetic, but the fragments will slip when the muscle tension has returned. We had best be satisfied with the fluoroscopic evidence for that day and take a film 24 hours later. A third film, showing 2 views, should be taken 2 weeks later.

Physical therapy. A fracture recovers best when the nutrition of the bone and those structures associated with it most nearly approach normal. Physical therapy aids in restoration of blood supply. It should begin, if feasible, when the treatment of the fracture begins, not after union has occurred.

Return to full function of weight bearing, etc., must be withheld until solid clinical union is found to be present. The roentgenographic evidence with regard to the rigidity of callus cannot be depended upon.

It has been our experience that the patient himself is his best physical therapist. It should be explained to him that return to function is his job, and that only by exercise, supplemented by massage and heat, can he get well. He should be carefully instructed in how to use all of these measures. Aided active motion should be explained to him. Pain is nature's warning of trouble. He will not injure himself but a physical therapist might. If a therapist is on the case at once, the patient transfers all responsibility to his shoulders, feeling that he, only a patient, does not know enough to conduct his own treatments. The individual is his best physical therapist even without the various baths, electrical rays, lights, currents, and other such measures.

It is not within the scope of this presentation to describe in detail the various efficient and yet simple dressings described by every treatise on this subject, but rather to call attention to the fact that the meticulous attention to the application of the simple fundamental principles of treatment will give the most satisfactory results, for the most patients, and the most physicians. Special intricate apparatus has its place in special conditions and in special hands.

RESULTS OBTAINED

Following the above principles of treatment our results have improved year by year. There has been an increase in the number of successful primary fluoroscopic reductions. Open reduction was necessary in only 7.3 per cent in the last 3 years of those cases serious enough to be admitted to the hospital. Metal, internal fixation material was necessary in only 18.3 per cent of cases. This reduction from the former figures of 33 per cent occurred very largely in forearm fractures; and open reduction results were good in 69.9 per cent, fair in 20.6 per cent, and poor in only 9.5 per cent.

CONCLUSIONS

1. A fracture implies soft tissue injury as well as a broken bone, and a fracture requires emergency treatment. Promptness is essential; the earlier reduction is attempted the easier reduction is accomplished.

2. Swelling should indicate action rather than delay, and the best way to reduce swelling is to reduce the fracture. Fluoroscopic control with local or spinal anesthesia is desirable. Position of muscle equilibrium reduces trauma and facilitates reduction.

3. Gentleness is indicated; thoroughness is essential but a cabinet-maker's reposition is not necessary to good function; and individuality is essential for best results. It is not the splint but the man behind it that produces results. Fit the treatment to the patient and not the patient to the treatment.

4. Deformity does not mean dysfunction; deformity with function is preferable to perfect restoration, but with loss of earning power. Function, necessary to the individual's livelihood, should be the goal.

THE CINEPLASTIC AMPUTATION

HENRY H. KESSLER, M.D., Ph.D., F.A.C.S., Newark, New Jersey

AMONG the large group of the disabled who seek the services of rehabilitation agencies, the amputation case is one that requires careful consideration. On the basis of the Cleveland survey, Faries has estimated the number of persons with arm amputations in the United States to be in the neighborhood of 33,000. While this appears to be a rather high estimate, it nevertheless calls attention to one serious type of handicapped patient whose rehabilitation becomes an important concern of all public agencies.

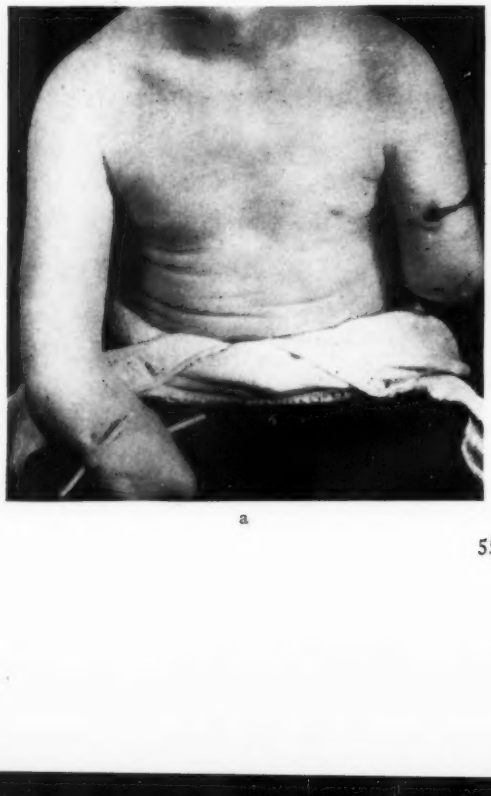
Many may rehabilitate themselves through educational or vocational aptitudes that are not affected by their handicap. Some have well adjusted personalities that make their social adjustment comparatively easy. The larger number, however, are unable to help themselves, and therefore, seek our aid. Employment is facilitated by providing these individuals with artificial appliances. The prosthesis serves to remove the psychological aversion toward the crippled by replacing the missing member. It likewise offsets the economic prejudice of the employer through the increase in industrial efficiency displayed by the amputee.

A man who wears an artificial leg is the least disabled of all cripples. Such a device not only substitutes for the weight bearing function of the natural leg but also eliminates the repellent attitude caused by the defect. Fitting an artificial leg is not a difficult task except in unusual situations.

On the other hand, the problems which face us in the fitting of an appliance to an arm stump are extremely difficult. In the case of an amputation of the arm or hand, the complete restoration of function by any mechanical means is quite beyond human invention. While it has been possible to imitate some of the simpler prehensile actions of the hand by jointed fingers, which can be flexed at will, this should not lead to an enthusiasm which is not warranted in fact and which raises only false hopes in the minds of the armless. The perfection of a mechanical hand with delicate selectivity has baffled inventive genius.

Only a small proportion of those supplied with artificial arms wears them and a still smaller proportion actually uses them. During the World

Presented in the Fracture Symposium, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.



a

b c

Fig 1. a, Traumatic amputation of both arms following trolley car accident; double motor in forearm and upper arm. (Courtesy of Drs. Goff and Yergason.) b, With prosthesis holding cup; c, use of prosthesis in bringing cup to mouth.

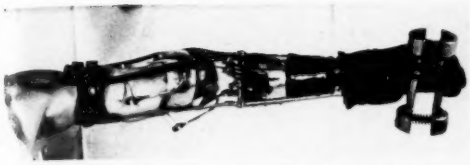


Fig. 2. Sixty-three year old lithographer. In this patient a cineplastic operation had been performed 30 years after the original amputation. Excellent muscle re-adaptation has been accomplished despite the long period of disuse.

Fig. 3.

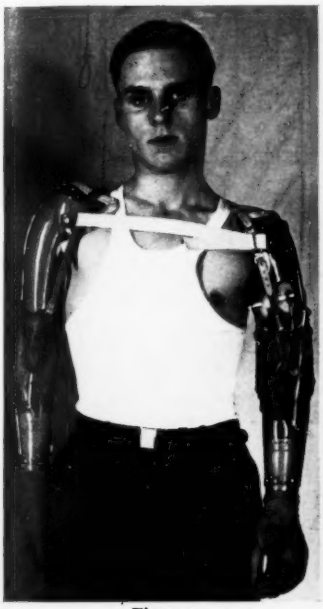


Fig. 3a.

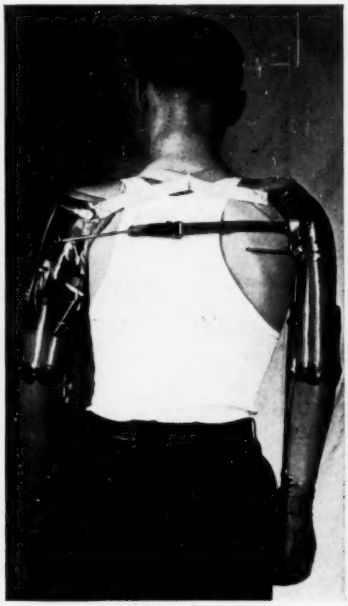


Fig. 3b.

Fig. 3c.

Fig. 3. High double-arm amputation following railroad accident. Practically no stump remaining in the right arm. Biceps and triceps muscles canalized in left arm and fixation canal prepared in right shoulder stump; a, front view with prosthesis showing peg through biceps canal; b, back view showing peg through triceps canal. Hand mechanism on left arm activated by biceps and triceps motors. On the right arm the elbow and hand mechanism is activated by cross straps on shoulders; c, showing patient fully dressed.

War our government permitted the armless veterans to choose any artificial arm on the market. Many chose complicated mechanical hands and arms which they soon laid aside as too cumbersome. In England the results were also disappointing. In 1918 the Ministry of Pensions made an inquiry into the use of arms furnished by the government and found that considerably less than half were using them. In Germany a survey made over a long period of years among a group of 7,000 arm amputations showed only 129, or 1.8 per cent, wore a mechanical arm (4). In a personal series of 1,500 arm amputations, 230 were observed over a period of 6 years. At the end of this period only 12 per cent of this group were wearing their artificial arms and 6 per cent were using them for work and in the routine pursuits of life.

The principal problem is that of making the stump play a supporting rôle in daily life and

Fig. 4. Traumatic amputation of upper third of forearm following industrial accident with double motors; a, at right, with prosthesis; note that apparatus does not extend above the elbow.

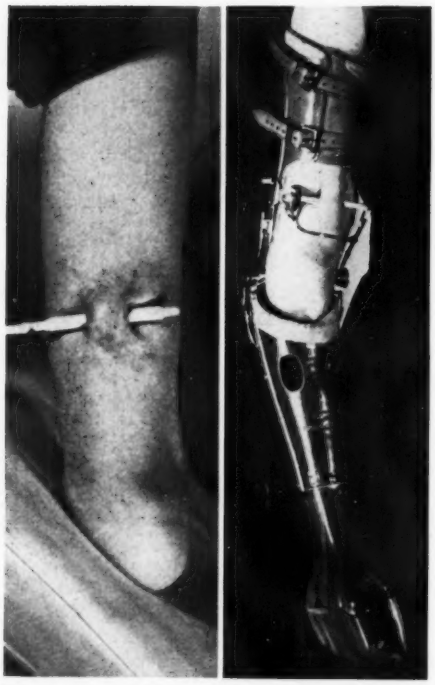


Fig. 5. Congenital amputation of left arm just below the elbow. In this case the biceps and triceps motors of the upper arm were utilized for activating the prosthesis; a, at right, with prosthesis.

Fig. 6. No attempt was made to revise the stump. Biceps motor canalized; a, at right, triceps motor canalized; note that above triceps canal is a small canal that was too superficial for active use.

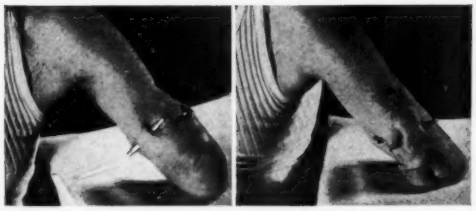


Fig. 7. Another irregular stump which was not revised; a, at right, showing both canals close to but avoiding the scar at the end of the stump.

Fig. 8. Disarticulation at the wrist with dorsal and volar motors; a, at center, another view showing the irregular contour at end of stump; b, at right, prosthesis for disarticulation not as satisfactory as amputation above wrist.

Fig. 9. Amputation just above the wrist with double motors; a, at right, with prosthesis. This is more satisfactory than disarticulation at wrist since there is some play between the end of the stump and the hand mechanism.

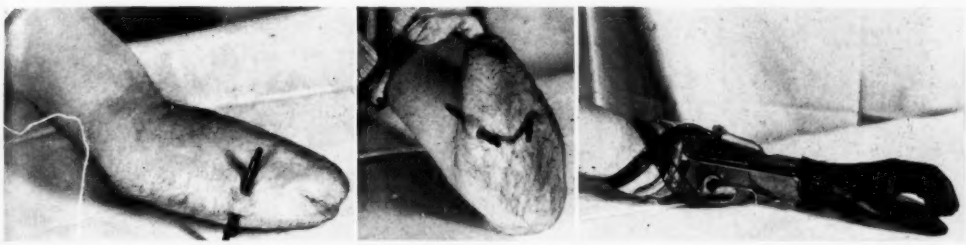


Fig. 10. Amputation at the junction of the lower and middle third of the forearm; a, at center, showing both motors with the elbow flexed; b, at right, with prosthesis.

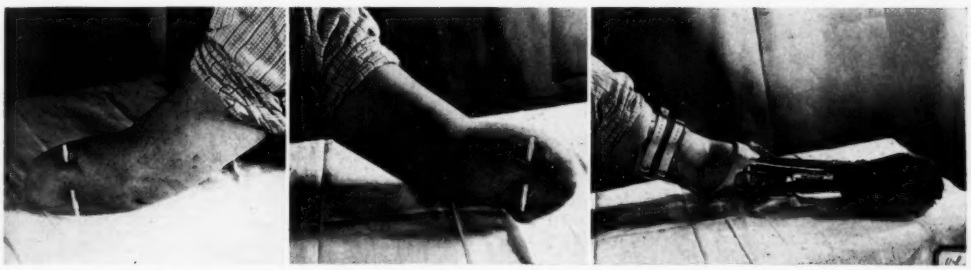


Fig. 11. Amputation of upper third of forearm, dorsal view; a, at center, showing both motors; b, at right, with prosthesis. Because of the short stump it is necessary to secure additional leverage by extending the apparatus above the elbow.

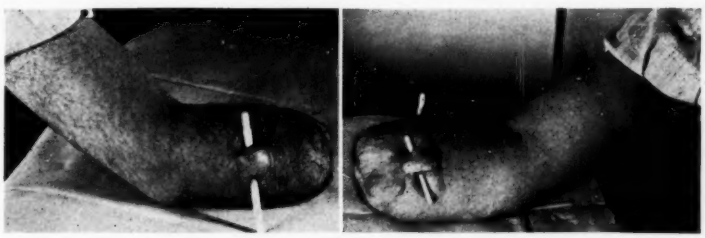


Fig. 12. Upper third of forearm amputation; a, at right, showing both motors.

Fig. 13.

Fig. 13a.

Fig. 13b.

Fig. 13c.

Fig. 13. Too short a forearm stump for utilizing the motors to activate any mechanism; canals are used for fixation only; a, showing apparatus with circular band fixed to the forearm stump; b, hand mechanism controlled by total movement of the forearm stump instead of individual motors, flexion of the elbow produced by strap attached to opposite shoulder; c, same in extended position.

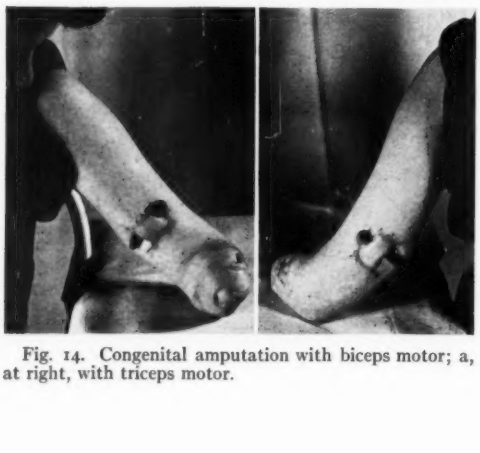


Fig. 14. Congenital amputation with biceps motor; a, at right, with triceps motor.

work. The expectations of persons with amputations are frequently too great. They hope to be capable of doing absolutely independent work through the artificial appliance. The use of the prosthesis, however clever it may be, is a limited one, since the safety factors retained by the body in its capacity for compensation may be more valuable than the best mechanical construction. For example, one-armed persons learn very rapidly to dress, undress, wash, shave and comb their hair, as well as to write with the remaining arm. The left hand gradually becomes the right hand and assumes all the tasks previously fulfilled by the right.

Because of the unsatisfactory experience with the ordinary mechanical arm, attention has been directed toward the development of a substitute

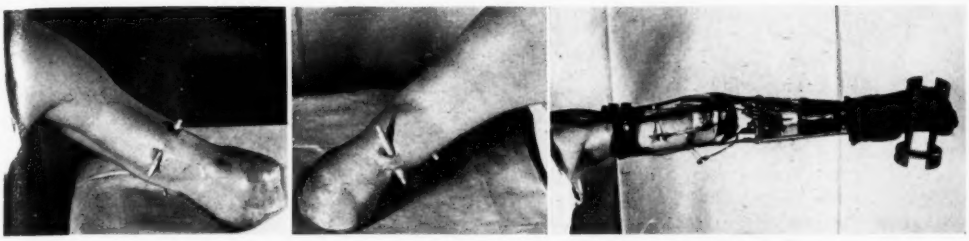


Fig. 15. Traumatic disarticulation of the elbow joint showing biceps motor; a, at center, showing both motors; b, at right, with prosthesis.

arm in which the control can be achieved by natural muscular action. This development is marked by the names of Vanghetti, Sauerbruch, Ceci, Putti, Pellegrini, and Bosch-Arana. Jottkowitz, in a survey of 729 cineplastic amputations, found 37 per cent of this group wearing their arms from 1 to 13 years after operation (5).

In the cineplastic amputation the remaining muscles in the amputated stump are utilized to activate the prosthesis. By means of pegs passed through canals in the muscles and attached to levers operating the artificial-hand mechanism, the physiological action of the stump muscles is restored. The biceps and triceps muscles in the upper arm and the flexors and extensors of the lower arm control the grasp and release of the fingers of the artificial hand. Thus, the stump retains its real task of guiding the hand without other problems added to it, such as leverage, in the case of a mechanical arm. Though the fingers of the artificial hand have no feeling, natural control is, nevertheless, exerted by the muscles in the act of grasping, thereby permitting a close approximation to natural hand function.

This report represents a preliminary analysis of the results of cineplasty in a group of 78 cases. While this series is too small for statistical treatment, it furnishes some basis for a discussion of advantages and disadvantages of this procedure.

Age group. The youngest case in the series was a 6 year old boy with a double arm amputation (Fig. 1). The oldest person in the series was an individual 61 years of age (Fig. 2). There would seem to be some advantage in performing this operation at an early age, while the wide variation in age range would seem to indicate that age in itself does not constitute any contraindication to the procedure.

Type of amputation and stump. The series included all types of amputations such as those due to public, street, and industrial accidents (Figs. 3, 4, 5), disease and congenital deformity. In none of the cases was any attempt made to revise the stump by secondary amputation. The stump was utilized even in the presence of scars and other deformities (Figs. 6, 7). Short congenital stumps of the forearm were unsatisfactory for muscle canalization. A single fixation canal permitted attachment of the entire stump as a unit to the activating lever of the hand. Flexion and extension of the stump at the elbow produced opening and closing of the hand (Fig. 13).

Site of amputation. This has varied from a disarticulation of the wrist to a very short or high upper arm amputation (Figs 8 to 22c). At this juncture it would seem pertinent to make a plea for consideration of a site for an amputation of the forearm. There is nothing to be gained by disarticulating or amputating at the wrist. Too long a stump is neither applicable for cineplasty nor for ordinary mechanical arms since the receiving extremity becomes much longer than the remaining extremity. Furthermore, the stumps are usually cyanotic and cold and have a tendency to break down because of poor circulation. From

Fig. 16. Traumatic amputation through the condyles of the humerus showing biceps motor; a, at right, same showing triceps motor.

Fig. 17. Amputation at the junction of lower and middle third showing both motors; a, at right, with prosthesis.

Fig. 18. Amputation about middle of upper arm showing the canal without the peg; a, at center, same, posterior view; b, at right, with prosthesis.

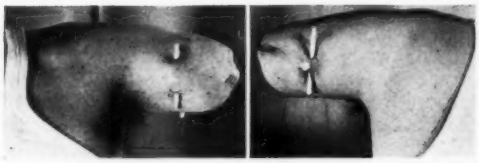


Fig. 19. High amputation of upper arm showing the method of utilization of the remaining biceps motor, a, at right, photograph of the same arm showing triceps motor.

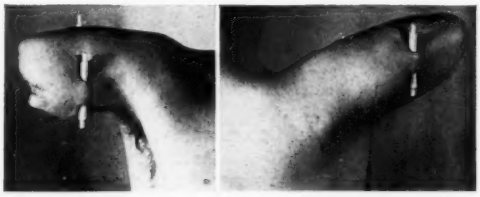


Fig. 20. High amputation of upper arm with both motors. Showing the feasibility of still utilizing the remaining musculature for reciprocal motors; a, at right, posterior view.

the standpoint of cineplasty, it is important to utilize the bellies of the muscle rather than the tendons: and so an amputation at the junction of the middle and distal thirds of the forearm is most suited for this procedure.

Time interval. In 2 cases cineplasty was performed at the same time as the original amputation. The longest time interval between the initial amputation and the time of cineplasty was 30 years. This would indicate that these muscles can be retrained even after prolonged periods.

Re-adaptation. In this series of 78 cases, 44 are now employed in remunerative work at such jobs as clerks, lithographer, painter, truck driver, inspector of transmission lines, watchman, track foreman, bookkeeper, leather embosser, machinist, elevator operator, fur sorter, laborer, accountant, inspector, helper in storeroom, needle board repair man (Fig. 23), commercial letterer, and stereotype operator.

COMPLICATIONS

Infection. In this entire series there were 3 cases of infection. In 1 case of congenital amputation both canals became infected, sloughed out, and were lost. In another case of infection the canal sloughed out but this case was reoperated on, another motor was made and the patient is

utilizing his cineplastic arm effectively (Fig. 24). In a third case the dorsal motor in a forearm amputation became infected, sloughed out, and the patient is now using a single motor cineplastic arm (Fig. 25). In still another case, that of a colleague referred to me for a prosthesis, the dorsal motor was made too deep, became ulcerated and was finally allowed to close. A spring is now utilized in place of the dorsal motor.

Fittings of prosthesis. In this entire series, the fitting of the prosthesis has been very satisfactory with the exception of 1 case. Only minor adjustments were necessary in a few cases to permit the amputee to utilize the apparatus immediately. With respect to repairs, the hand is exceedingly light, is made of wood and from time to time

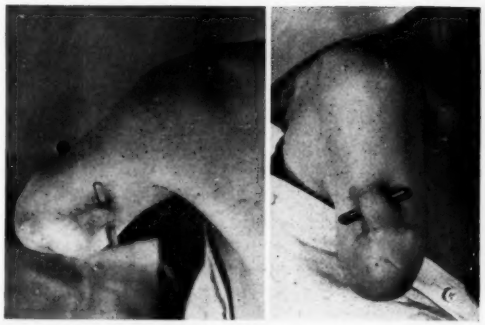


Fig. 21. High amputation with double motor; a, at right, posterolateral view.

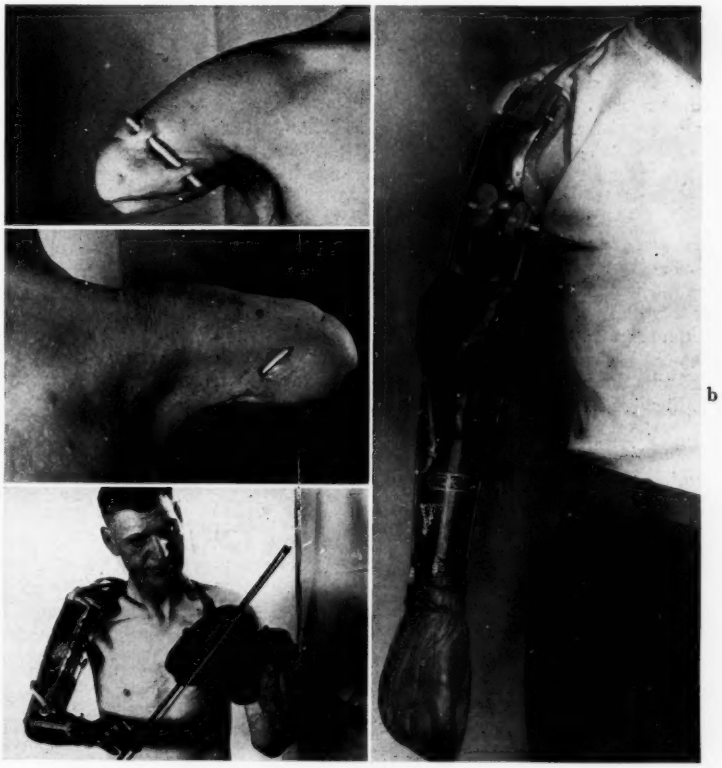


Fig. 22. High upper arm amputation with extensive scarring leaving very little muscle, part of the deltoid and short head of the biceps were canalized and both utilized as one single motor; a, the triceps was utilized as a reciprocal motor; b, with prosthesis; c, the use of the prosthesis in playing the violin.

fingers are knocked off but can be glued back again. Where the work requirements are such as to indicate need for an arm of heavy construction, this can be supplied by substituting a metal hand, or wooden hand re-inforced with metal.

Unsatisfactory results. The difficulties that do arise can be ascribed to 3 factors: the patient, the operative procedure itself, and the prosthesis.

The patient. Unless the patient is co-operative, the best surgical result and the best type of prosthesis will be useless. The expectations of the amputee are frequently too great. He expects to duplicate the physiological act of prehension with all its infinite variations. Even with ordinary mechanical arms, the individual is deceived by the unusual skill of the salesman. The latter, by dint of years of practice and adaptation, has achieved an almost artistic perfection, one which the new amputee cannot accomplish in a short time. Discouraged by his lack of success, the limb is soon discarded. The cineplastic arm has the advantage of depending on a natural physiological process. The re-education occurs in a simple manner in a short space of time.

OPERATIVE PROCEDURE

The site of the motor is selected and a 3 sided flap of the skin and subcutaneous tissue turned up, each side being 1½ inches long. The skin tube or loop is prepared by reversing the flap and securing the end of the tube with a silk suture. The rest of the tube is approximated with subcuticular sutures of fine gut closely placed in order to insure perfect apposition. The tube is retracted and the muscle prepared for canalization. Two parallel incisions are made in the muscle belly and an instrument passed through the muscle to form a canal.

The skin tube is then passed through the canal, holding the traction suture in the most superficial position in order to avoid distortion of the tube. The edge of the tube is sutured to the adjacent skin. This leaves a skin defect which must be closed. In young children, in the upper arm in adults, and in those cases in which there is a redundancy of skin in the amputation stump of the forearm, it is possible to close the defect by direct approximation of the skin edge. More frequently this cannot be accomplished without danger of skin necrosis. In this event the wound defect is covered with a Thiersch graft. Zeroform gauze wicks are then inserted in the canals. The first dressing is done in about 10 days, the pegs are inserted in about 3 weeks, and the stump is ready for prosthesis in about 6 weeks.

There are only a few points that need emphasis to avoid failure. It is most important to select

Fig. 23. Forearm and upper arm amputation in use in factory where needle board is being repaired.

the proper muscle or muscle group for canalization. It is impossible to tell beforehand just which muscles remain after the amputation. We depend, therefore, on the clinical test of visualizing the contraction of the muscles to be selected in response to the psychophysiological act of opening and closing the hand at the site of amputation. The patient must, therefore, be awake and the muscles outlined with a skin dye just before the operation is undertaken.

The second important step, neglect of which has been responsible for many failures in the past, is to canalize the muscle and not the tendon. The latter has no contractility. The activation of the artificial hand mechanism depends on the movement of the peg which passes through the tube. This movement varies from ¼ to ½ inch and is due to the alternate shortening and lengthening when the muscle contracts or relaxes.

The prosthesis. It is not difficult to manufacture the cineplastic arm. It is important that the weight of the apparatus be kept to a minimum. Furthermore, the mechanism should be as simple as possible. The more complicated the prosthesis, the less useful the arm. Theoretical advantages should be sacrificed for practical utility. For example, there is no need for incorporating a rotation mechanism at the wrist in forearm cases, since pronation and supination of the stump are still retained. However, in upper arm amputation, this rotation mechanism is of distinct value.

The arm can be designed for heavy as well as light duty, depending on the indications in the specific case. In the forearm amputation, no straps or apparatus are required above the elbow. In the upper arm amputation, a strap to the opposite shoulder is necessary to secure flexion of the elbow.

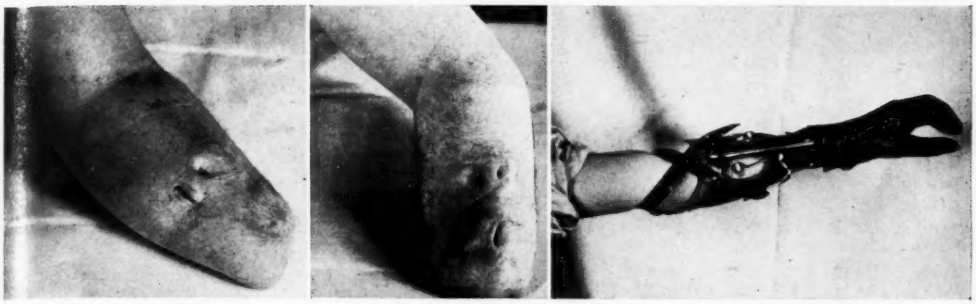


Fig. 24. Volar aspect showing canal intact; a, at center, dorsal aspect showing two canals. The proximal canal has been lost by infection; sufficient room remained for making a distal canal; b, at right, the hand in use with prosthesis.

The results of this cineplastic amputation in a series of 78 cases are distinctly encouraging. Of this group, 44 may be classified as highly successful. These individuals are consistently using the prosthesis at work and in the routine pursuits of life over a period of from 2 to 6 years.

Of the 34 remaining, 19 enjoy partial utility of their prosthesis. Unusual work requirements may render it impractical even to wear the arm at work, as in the case of 1 worker in a chemical plant who must immerse both arms in a solution as part of work operation.

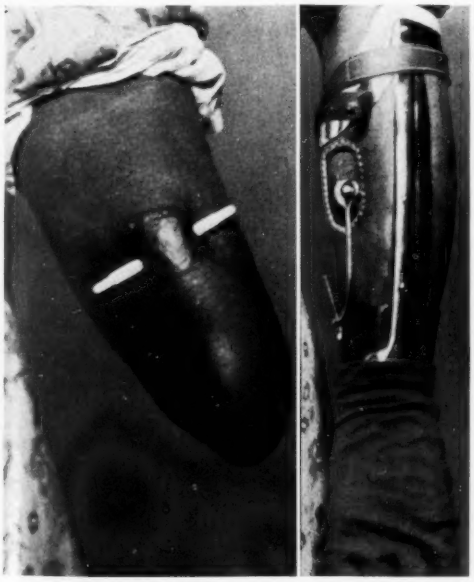


Fig. 25. Single volar motor; a, prosthesis for single volar motor; volar motor closes hand and spring is utilized for opening hand.

Of the 15 that can be classified as failures, 5 have been due to surgical complications. Infection of the skin tube, necrosis due to previous x-ray dermatitis, improper placement of canals, too short a stump for utilization of leverage of muscle motors, and improper fit of prosthesis account for these failures. The remainder found it difficult to adjust themselves because of personality factors.

CONCLUSION

The use of the cineplastic amputation in selected cases is of distinct advantage in the rehabilitation of the armless. Through the natural control obtained by this procedure the individual is able to utilize the assistance of the amputated arm in the performance of his daily tasks. By increasing his efficiency, he restores his confidence in himself and his ability to compete with others. He is thus equipped to partake of a fuller life without asking for any special considerations.

REFERENCES

1. Bosch-Arana, G. Semana méd., 1921, 566: 301.
2. Ceci, A. Amputazioni plastico-ortopediche secondo Vanghetti. Cong. ital. di chir., October, 1905.
3. Faries, J. P. Limbs for the Limbless. New York: Institute for the Crippled and Disabled, 1934, p. 13.
4. Jottkowitz, P. Ergebnisse der orthopaedischen Versorgung der kriegsbeschaedigten Armamputierten Deutschlands. Arbeit und Gesundheit, 1931, 19: 29.
5. Ibid. p. 35.
6. Little, M. E. Artificial Limbs and Amputation Stumps. Philadelphia: P. Blakiston's Son & Co., 1922, p. 87.
7. Pellegrini, A. Chir. d. org. di movimento., 1917, 1: 5.
8. Putti, V. Chir. d. org. di movimento, 1917, 1: 292.
9. Sauerbruch, F. Die willkuerlich bewegbare kuenstliche Hand. Berlin: Julius Springer, 1916.
10. Vanghetti, G. Amputations, disarticolazione e protesi. Florence: 1898.

FRACTURES OF THE BONES OF THE FACE

JAMES BARRETT BROWN, M.D., F.A.C.S., St. Louis, Missouri

FACTORS of importance in extensive facial injuries may be listed as follows: (1) When a patient is examined, following a severe blow about the face, it is best to suspect a fracture and work from that point. If it is assumed that the possibility of fracture can be considered when the swelling has gone down, or, if soft tissue repairs are carried out with disregard for displaced bone fragments, the best chance for correct bone replacement has been missed. (2) Possibilities of good repair are present in almost all instances but must be met promptly and adequately. (3) Simple procedures of accurate replacement and holding of bone and soft parts, drainage and bandaging, should suffice; and, with relatively simple equipment, sound care usually can be afforded these patients. (4) The reverse is true if the full picture is not clear to those in charge and restorative measures are lax. (5) Although the lesions may be multiple, complicated splints and traction are seldom required and may actually be detrimental in some instances. It is important, however, to have available someone cognizant of the dental requirements and means of fixation, because one of the most important functions to be preserved is that of mastication, and this requires that the teeth come together in normal occlusion. (6) The problems presented by fractures about the upper part of the face require careful evaluation, and diagnosis; if tissue has been completely lost, this point is of extreme importance in the final outcome, and the extent of loss should be recorded either in the original examination or at the time of operation. (7) Skull fracture and brain injury are so frequent that neurological examination, including x-ray films, often must be made, and local repair delayed if there is any lesion that requires treatment or complete rest. Patients who receive "snap" blows about the head may have damage to the cervical spine and, on the slightest indication, this region also should be checked with the x-ray. (8) Ocular damage is very frequent and is often the main indication for treatment. (9) Although good position and function may be obtained, final bony union may never occur in many instances. This may be due to the very thin edges of bone, that simply do not unite, and also to prolonged infection. In the lower jaw there may be solid union but with persistence of the fracture line on x-ray.

From the Department of Surgery, Washington University School of Medicine.

Presented in the Symposium on Fractures, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

ASSOCIATION OF BONE AND SOFT TISSUE DAMAGE IN COMPOUND INJURIES OF THE FACE

The lacerations, avulsions, and tears of the soft parts, and the fractures and displacements of the bones may be so numerous that it may be difficult to list all the diagnoses, and the term, "compound injury of the face," could be used as a rough classification. Although widespread, soft tissue damage often occurs without fracture, and very extensive, comminuted fractures result from blunt force, which may not even break the skin, the 2 occur together so frequently that it is not possible to separate completely the repair work of bone and soft tissue.

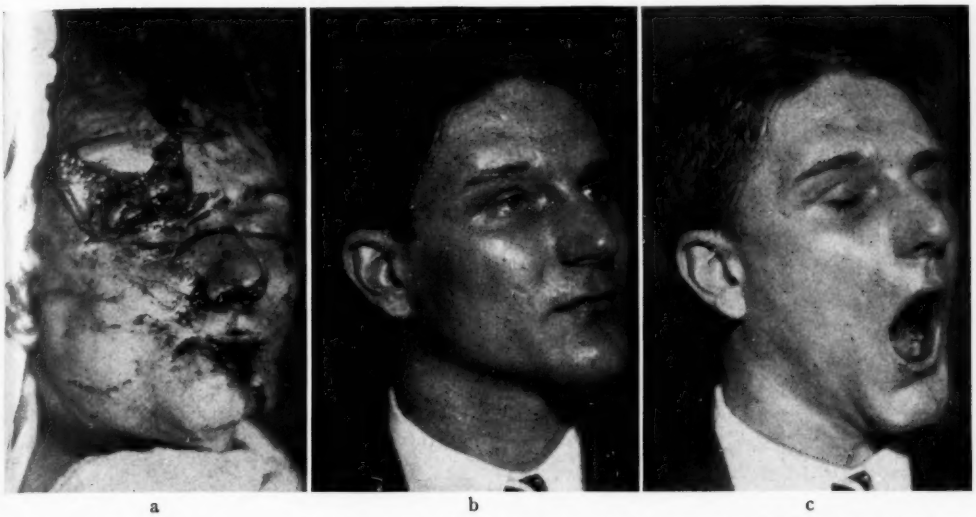
X-RAY EXAMINATION

It is not necessary to rush these patients to the x-ray room, because most operative procedures can be done without the pictures, and the necessary manipulation in the x-ray room might be contra-indicated if there were skull or cervical spine damage. However, when safe for the patient, complete views of all involved regions should be taken.

In roentgenograms of the upper jaw the heavy ridges of bone show quite well in antral and in verticosubmental positions, but there may be many comminutions of the maxilla, ethmoid, nasal, and other thin bones that are entirely missed on the x-ray plate and, therefore, this condition has to be searched for at the time of operation. Complete skull and cervical spine series should be taken as indicated before. For the lower jaw complete views of both sides, including both condyles, should always be taken, because multiple fractures may be missed even at operation. The laminograph, developed by Dr. Sherwood Moore and designated as body section radiography, gives the most accurate information of the joint area.

PRIMARY REPAIR TO BE DONE EARLY IF POSSIBLE

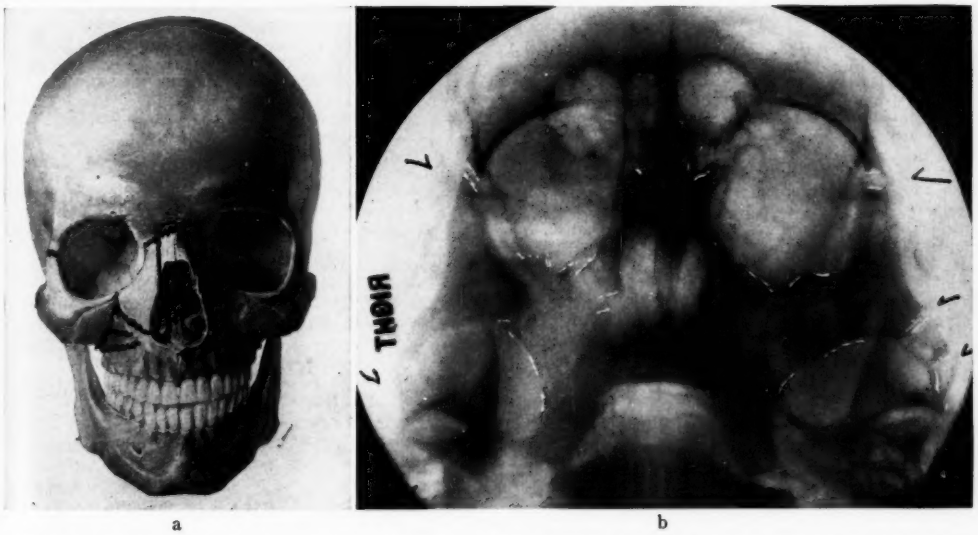
These wounds and fractures should be cared for in the first 20 hours if possible, before excessive



a b c

Fig. 1. a, Extremely widespread soft tissue injury plus complete separation through the symphysis. b and c, Complete restoration in 1 operation which was done a few hours after the accident.

swelling, organization of clots, and infection have occurred. This necessitates work at odd hours of the day and night, and it is recognized that the statement has been made frequently that the repair of facial injuries should be delayed several days. If the patient is seen after this time and



a b

Fig. 2. a, Diagram of frequent separations of the upper jaw, to which should be added a loosening all the way around on both sides just above the alveolus. b, Multiple comminutions of the facial bones, some of the areas having been scratched in for clearness. Separation of the zygomatic-frontal suture lines on both sides, crumpling of the zygomatic arches, and comminution about the orbital borders and antrum.

a b c

Fig. 3. Representative patient with complete facial separation. a, Patient who had suffered multiple comminuted fractures of practically all the bones of the face shown 3 weeks after operation which was done under basal and deep block anesthesia 1 week after the accident. The *nose* was completely loose and shattered, and, as a result of swelling, was just on a level with the cheeks. An air-way was established through both nostrils with a long speculum and maintained with rubber tubes, the palatal processes had cut through the palate in 2 places and these were forced back into place at the same time. The dorsum of the nose was elevated and held with a double sling of silver wire from side to side, put through the fracture lines along the frontal processes with large cutting needles and held on the side of the nose over lead plates as shown. The *inner canthi* were widely separated by an actual chiseling open of the face as the nose was driven backward. The canthi were replaced at the same time the nose was elevated and the fixation of the nose has helped to assure correct position and direction of the inner canthi. The *orbital borders*, *zygoma* and *antrum* are considered together because, as the zygoma is loosened, the border goes down and the antrum crumples under it. If the zygoma is driven backward, the zygomatic process of the temporal bone is crumpled either in or out. Restoration is done by making a small incision in the upper buccal fornix, entering the antrum through the fracture line and then replacing the orbital border, the frontal process, and the bulk of the zygoma and, if necessary, packing the parts in place by filling the antrum carefully with an iodoform gauze pack. The fragmented zygomatic process may be carried inward by external pressure, or lifted out with a small hook under it, placed either from the outside, through the mouth, or down from the temporal region as suggested by Gillies. The *upper alveolus* was broken in all the way on the left and was carried back into position and held with direct wires on the teeth across the fracture line and finally with fixation to the lower jaw. The *lower jaw* was broken through the symphysis and was held with the type of fixation shown in Figure 5b; the upper jaws were used to support the lower and vice versa, although both were broken. b and c, Shows complete restoration of contour with normal expression, normal position of the inner canthi, no diplopia, normal vision, and normal occlusion. The most prominent feature of the profile, the dorsum of the nose, is restored. 1 operation.

there would be the necessity of manipulation through contaminated clots and edematous tissue, the replacement of bone might be delayed until there is subsidence of the swelling, although the soft parts might still be approximated. The replacement of bone fragments should not be delayed longer than 7 to 10 days under nearly all circumstances because the fixation of small, comminuted chips after this time may make impossible their correct alignment.

Shock and neurological damage may necessitate delay in early repair; and, if a patient is intoxicated, the jaws should not be wired together.

GENERAL CONSIDERATIONS OF THE OPERATIVE PROCEDURES

It may be best to wait until the patient is in the operating room before any manipulation is done, so that there will be the least discomfort. Then a complete analysis should be made of what is nec-

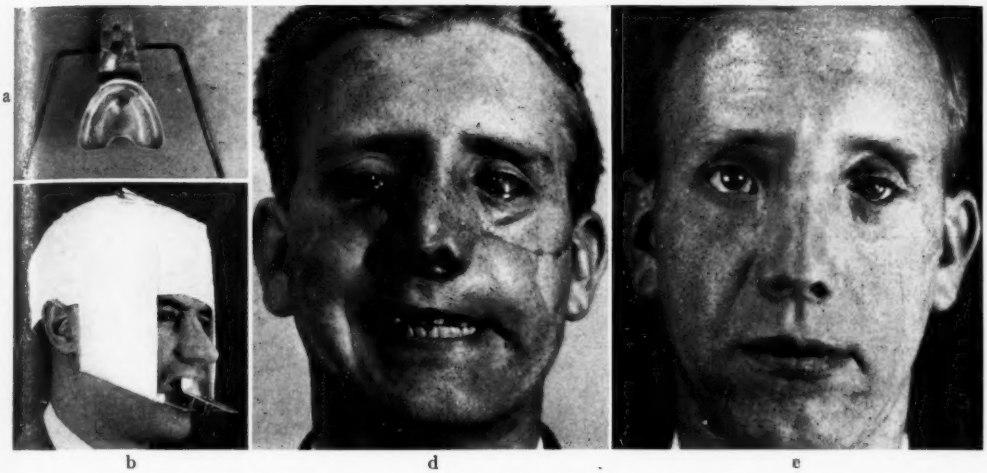


Fig. 4. a, b, Simple type of splint for elevating dental arch and face. Made by Dr. J. A. Brown for use in patient shown in d and e. The tray is filled with dental compound before it is used, and is held with a simple elastic sling from the top of the head. d, Patient with blindness in left eye, complete transverse and multiple facial fractures with almost total loss of the left upper jaw. e, Restoration of occlusion, nasal position, and of the cheek prominence with a free costal cartilage transplant. The right inner canthus is still somewhat displaced, as evidenced by the sharp curve of the tarsal border.

essary in order to carry the repair, in definite steps, to completion. For example, the patient in Figure 1 was so uncomfortable because of a symphysis fracture that this was fastened together first, by drilling and direct fixation of the fragments. He was immediately more comfortable, and then the repair of the floor of the mouth, chin and lip was completed. Next, the upper part of the face, nose, ear, eyelid, and scalp were repaired; and by using clean instruments, gloves, and drapes throughout, there was no further mouth contamination.

Anesthesia is usually obtained with novocain, locally, or by deep block of the second and third division of the fifth nerve. A basal drug can also be given, but general anesthesia should be avoided, except that it is necessary when dealing with children.

DÉBRIDEMENT AND PRESERVATION OF TISSUE

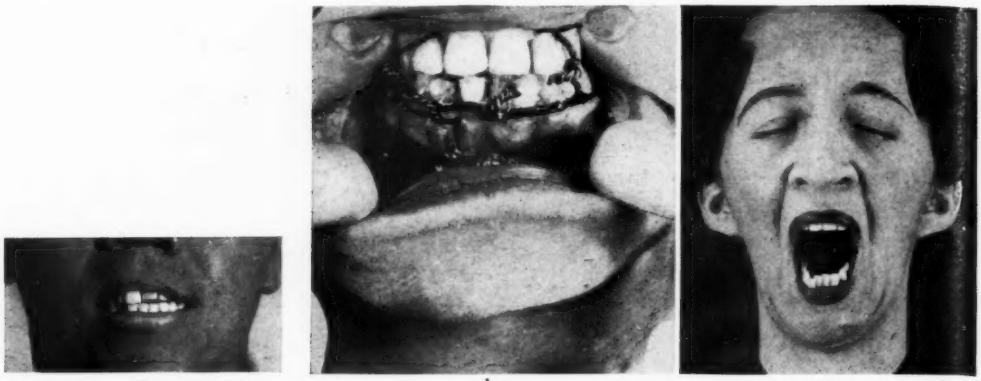
Cleaning of these facial wounds is extremely important and should be done with soap and water followed by ether and saline irrigations so that local antiseptics are seldom necessary; anesthesia may have to be given before the cleaning is completed because of pain. Oil ground into the face should be scrubbed and dissolved out completely. Bits of glass from rear vision mirrors or from completely broken shatterproof glass are especially apt to be overlooked, and for this reason it is well, if possible, to find out whether or not any glass was broken at the time of the accident so that search may be made accordingly.

Débridement should be done very sparingly both of soft parts and bone. If the usual idea of wide excision of torn edges were applied, many parts of features would be needlessly sacrificed. In dealing with loose bone chips extreme conservatism should be adhered to, and it is probably better to leave in some bone fragments that might die rather than adopt the policy of removing all loose fragments and thereby possibly discard many good supporting fragments that might live.

SUTURE OF SOFT TISSUE

As stated, the repair of jaw fractures cannot be totally separated from the repair of the soft parts and, therefore, a brief summary is included here.

In complicated tears such as shown in Figure 1, a correct replacement may be difficult, but a start is made at some known point such as the nostril border, or the edge of the eyebrow. If none can be figured out, closure may be started in the center of a wound and the remaining segments bisected with sutures until there is complete closure. If flaps are torn loose in a trap-door or triangular manner, their correct re-approximation is extremely important if involving a feature. In this



a b c

Fig. 5. a, Permanent loss of occlusion in upper jaw fracture which might have been prevented by using the lower jaw for a splint by simply wiring the 2 jaws in occlusion. b, Method of Risdon in applying an anterior arch by putting long wires on the posterior teeth, bringing them around in front, fastening them together, and then anchoring individual teeth to this arch with finer wires. Besides this support, which is used mainly for symphysis fractures, fixation to the upper jaw with the teeth in normal occlusion is done and support applied from the chin to the vertex, if necessary. c, Functional result obtained in a patient with a fracture at the symphysis and through both condyles as well as a separation in the left upper jaw by using the fixation shown in b.

patient (Fig. 1), the entire eyelid was closed in a position too far advanced on the forehead, and the lid had to be opened completely and resutured before the patient left the operating room.

Close attention should be paid to the wound edges to see that they are in apposition, and, of course, very ragged edges should be cleanly excised. The first sutures may have to be deep but should never be placed far from the wound edge because wide suture marks can never be completely obliterated. Many times widely placed sutures may be put in, however, but left open until the entire wound is closed; then they are tied over a gauze pad to bind the wound closely together and to avoid the surface cutting of the suture.

It is best to effect complete closure of the wound with deep, fine No. 000 white silk sutures so that, when the final skin sutures are inserted, they are merely to support the edges and adjust them. If possible, stay sutures may be put in from the inside of the cheek or nose.

Small drains may be placed advantageously, and firm, pressure dressings of mechanic's waste or marine sponges can be applied finally to control hemorrhage and swelling and, thereby, infection.

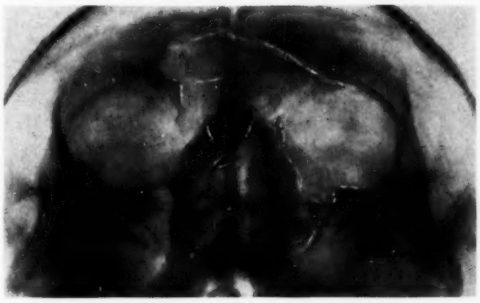
DISPLACEMENT OF THE BONES OF THE UPPER JAW

Transverse facial fractures occur usually from heavy blows dispersed over the face. There may be a level of separation at the frontal-zygomatic suture line and at the glabella on both sides; there may be one through the wall of the antrum that may extend all the way around and involve the pterygoid region; and frequently there is a complete separation entirely around just above the dental arch. The whole face may sag down and become noticeably elongated, and the dental arch may be completely loose to the patient's own sensation and on moving it with the examining fingers (Figs. 2, 3, 4, 5, 6).

Nasal, septal, and palate fractures frequently occur along with the above separation, and these small thin bones may be comminuted into multiple pieces. The nasal structure, including the cartilages, may be completely crumbled, and there may be one or more complete lacerations through the palate caused by the disrupted bone cutting through; the nasal passages may be completely occluded also (Figs. 3, 6, 10).

The zygomatic bone and orbit. The zygomatic bone (malar or cheek bone) frequently receives the blow but is itself seldom broken. Instead, it is torn loose from its moorings at the frontal, zygomatic process of the temporal bone and the maxilla. The main displacement will be according to the direction of the force; if, from the front, the zygomatic process will be crumpled back and broken by the zygoma itself; if, from the side, the ascending ramus of the zygoma may be tipped in and impinge on the orbital space. In nearly all loosening of this bone, the antral wall crumples, and, should it sag down too much, the orbit becomes elongated and the globe may descend so

b c d



a

Fig. 6. a, Comminution of the facial and frontal bones with involvement of the frontal sinuses, displacement of the inner canthi, and flattening of the nose. b, Patient seen a few hours after the accident and restoration done immediately, that is, replacement of the comminuted fragments, rubber tube left in frontal sinus to drain into the nose, fragments of nose held up and inner canthi replaced by through-and-through silver wire sutures, placed through the fracture lines of the frontal processes and held over lateral lead plates on the outside of the nose. c, d, Restoration of the nasal bridge and normal direction and situation of the inner canthi (one operation).

much that binocular vision is impaired (Figs. 3, 4, 7, 8, 9, 11). Blindness may result from section of the nerve by a loose, thin piece of bone and from intra-ocular or direct ocular damage. The extra-ocular muscles and nerves may also be torn (Fig. 4). The lacrymal apparatus may be impinged on if the frontal process of the maxilla is driven in.

Inner canthus displacement occurs if the nose with the frontal processes of the maxilla is crushed backward, there being an actual chiseling open of the front of the face. This deformity is as important as any other in which to accomplish an early repair, because, if left until fixation occurs, the canthi probably never will be sunken in normally again (Figs. 3, 4, 6, 11).

Nasal flatness goes along with the canthus displacement and the two are corrected together by withdrawing the depressed tissues and bones, molding them into their normal positions, and frequently holding them there with through and through silver wire sutures inserted under the separated frontal processes and held on the outside of the nose over lead plates (Figs. 3, 6, 10).

The general rule for repair is simply to replace these fragments and maintain them in position with the least manipulation possible. This replacement amounts to an open reduction, and access to the orbital border can be gained by a short incision in the buccal fornix, then into the antrum through the fracture line that is almost always present. The depressed border can then be elevated into position with a Kelly clamp. This bone may be locked in place, but, if there is much comminution, the whole number of fragments, including the anterior and lateral walls of the antrum, may be "mulched" in position and held with an iodoform pack in the antrum, with the end left just through the opening in the fornix.

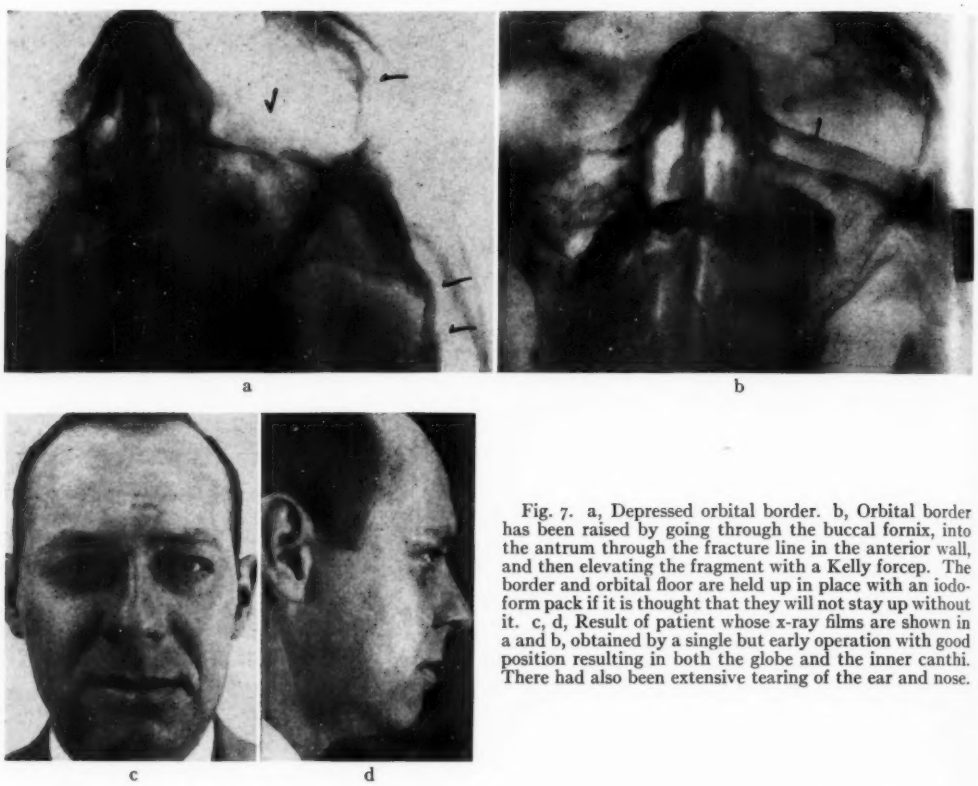


Fig. 7. a, Depressed orbital border. b, Orbital border has been raised by going through the buccal fornix, into the antrum through the fracture line in the anterior wall, and then elevating the fragment with a Kelly forcep. The border and orbital floor are held up in place with an iodoform pack if it is thought that they will not stay up without it. c, d, Result of patient whose x-ray films are shown in a and b, obtained by a single but early operation with good position resulting in both the globe and the inner canthi. There had also been extensive tearing of the ear and nose.

If there is derangement of occlusion, the lower jaw can be used to splint the upper by fixation of the teeth followed by the application of a bandage from the chin to the top of the head. Frequently, the closing power of the muscles attached to the lower jaw will suffice for this, and the overhead pull can be omitted (Figs. 4, 5).

ILLUSTRATIONS OF GENERAL TYPES OF LESIONS

The most frequent lesions are described by the following representative patients, and the legends of illustrations may be followed as part of the text:

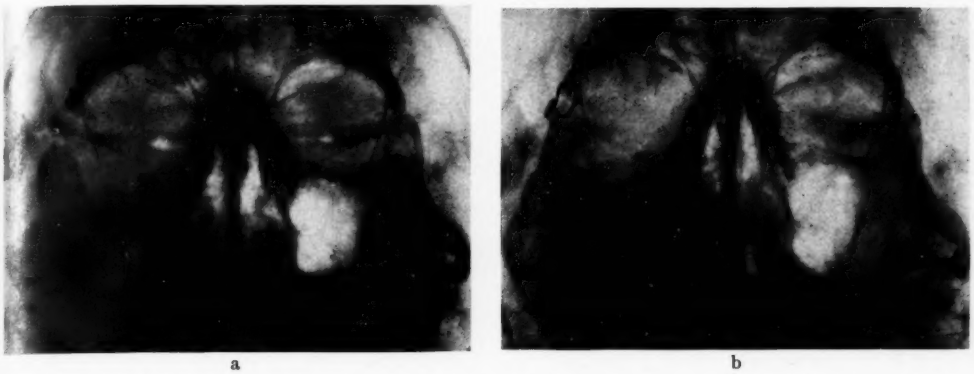
Restoration of contour after complete facial fractures without special splints. Diagrams and roentgenograms of typical complete facial separations are shown in Figure 2, and a patient, completely restored after the most extensive facial fractures of this type, is shown in Figure 3 with the operative procedures outlined in the legend.

Elevation of sagged upper jaws with dental splint. In Figure 4 a simple type of apparatus for elevating upper jaws is shown, made by Dr. J. A. Brown, for use in the patient shown in Figure 4, d and e. This does not insure normal occlusion, and, when it is removed, if there is any tipping of the upper alveolus, the teeth should be forced into their normal occlusion and held there by interdental wiring to the lower jaw, and, if necessary, support should be applied from the chin to the head.

Blindness in compound facial injury. The patient in Figure 4, d and e, illustrates the loss of vision frequently seen, and shows fairly normal replacement of the soft parts, re-establishment of occlusion and the building out of the depressed left cheek with costal cartilage.

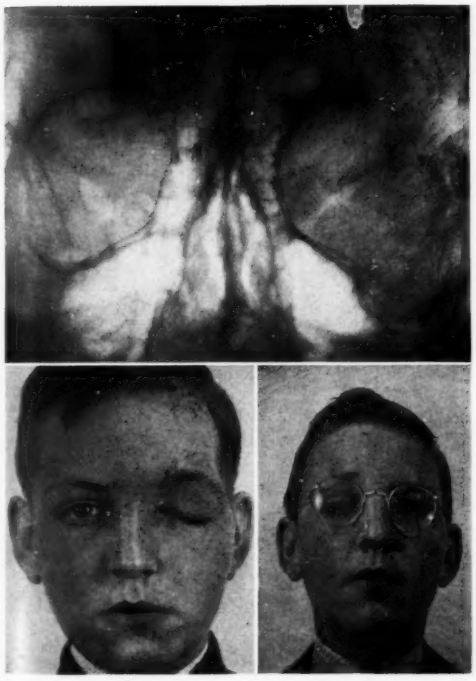
Loss of occlusion in upper jaw fracture is shown in Figure 5a where interdental fixation with the teeth in occlusion had been omitted.

Anterior dental arch plus jaw-to-jaw fixation is shown in Figure 5b, the type used in the patient in Figure 3 and also in the patient in Figure 5c, who had a symphysis separation and fractures of



a b

Fig. 8. a, Marked displacement of entire zygoma after 2 weeks with no hope of holding it in position from the inside of the antrum, because it is broken so far away laterally from any support. b, Zygoma replaced and held by direct wiring from ascending ramus to frontal bone; access to bone gained by opening a scar of accident. This elevation is usually not successful if fragment becomes firmly fixed out of position; then globe has to be elevated within orbit (see Fig. 9).



a b c

Fig. 9. a, Loss of lateral wall and floor of orbit so that no elevation is possible. b, Patient whose x-ray film is shown in a. The main object of restoration is for eye function, as there is marked depression of the bony orbit, complete ptosis of the lid, and paralysis of the frontalis. c, Globe elevated with 1 block of free costal cartilage and held medially with another. With this replacement of the globe there was subjective improvement in the ease of ocular movements. Binocular vision does not always return after this procedure because of the delicate balance necessary for this function. Elevation of the lid was obtained by a fascial loop to the forehead and a second long one from the temporal fascia through the tarsus to the opposite frontalis. The upper orbital border was restored with a costal cartilage transplant put in a periosteal sling to give good fixation of the graft. All 3 pieces of cartilage were fresh homografts from the mother.

both condyles. This illustrates the use of the lower jaw to splint the upper.

Fractures through the frontal and ethmoid sinuses; inner canthus displacement. Sinus involvement is shown in Figure 6 with the fracture through the wall of the frontal, and with wide separation of the inner canthi and complete flattening of the nose, repaired so that practically normal position of the canthi and of the nasal dorsum results with a simple fixation as shown in Figure 3c.

With involvement of the frontals and ethmoids there is some possibility of direct dural contamination, and the added precaution must be taken to maintain drainage into the nose without irrigation or manipulation that might carry infection up to the dura. If the sinuses are already infected, the chance of spread is greater.

Elevation of orbital border through buccal fornix; incision and antral fracture line. In Figure 7 the inner part of the orbital ridge is down in a and is back in place in b, supported with an iodoform pack in the antrum. In c and d the normal profile and, from the front, the normal position of the globes and the inner canthi are shown.

a b c d e

Fig. 10. a, Complete depression of the nasal dorsum from injury without loss of tissue. b, c, Complete restoration of dorsum by chiseling free the depressed bone and cartilage and holding it forward on a mattress wire sling. d, e, Depression following injury plus loss of tissue so that free cartilage transplant is necessary for elevation as in e.

Zygomatic bone versus zygomatic process fractures. Some confusion has arisen in relation to these two fractures both of which are illustrated in Figure 7 a and b. The zygomatic arch is part of the temporal bone and is broken only occasionally by itself but is often crumpled in or out by fractures of the zygoma. The various maneuvers, recommended to lift out zygomatic process fractures, do not usually apply to true displacements of the zygoma itself.

a b c

Fig. 11. a, Depression of frontal area, deformity of lid and inner canthus. b, Result of "backing" tissue down into lid from forehead in V-Y procedure through old scars. c, Result of fastening tarsal border to frontalis muscle for elevation of lid, and of filling the bony depression with free fascia.

Direct fixation of a completely loose zygoma is shown in Figure 8 by drilling the frontal bone and the ascending ramus of the zygoma and anchoring them together. It was done in this instance because the very loose bone could not be supported from inside the antrum.

Consideration of late deformities. If the late deformities are studied, the requirements of early care may be made more clear; and, since many secondary corrections have to be made, some responsible person or the patient himself should be told of this possibility in all severe injuries.

Elongation of the orbit because of depression and loss of zygoma is shown in Figure 9. Restoration of eye level has been obtained by elevation of the globe with costal cartilage transplants along the floor and in the lateral region.

Late restoration of nasal bridge and profile, using the tissues that have been crumpled in, is shown in Figure 10, a, b and c. The depressed bone and cartilage dorsum was literally dug out of its enfolded position and then held forward on silver wire slings from side to side.

Late restoration of profile with costal cartilage transplant is shown in Figure 10, d and e, where it has been recognized that tissue has been lost at the time of the accident or from infection. Elevation is effected with transplanted costal cartilage cut in one large piece to replace the entire loss of the septum and give support to the tip through the columella.

Filling in of skull defects, secondary soft tissue correction, and correction of traumatic ptosis, is shown in Figure 11. The lid has been brought down so that closure can occur, by "backing" some of the forehead tissue down into the lid in the form of a V-Y operation and going only through the old scars. The depression of the forehead has been filled with a free fascia lata transplant. Cartilage may also be used for this. The residual ptosis has been corrected with a free fascial loop from the tarsus to the frontalis muscle.

DOUBLE PIN SKELETAL FIXATION IN FRACTURES OF THE LEG

R. ARNOLD GRISWOLD, M.D., F.A.C.S., and GEORGE W. HOLMES, M.D.,
Louisville, Kentucky

CHANGES in automobile design a few years ago had a profound effect on the treatment of fractures of the leg. The most important factor was the increase of power, speed, and force of impact, which caused great damage to both soft and osseous tissues and resulted in a larger percentage of compound injuries. Four-wheeled brakes and smaller wheels changed the usual point of impact on the pedestrian from the knees to the mid-third of the leg. The result has been severe crushing injuries to the leg, with extensive damage to the bones and soft parts. The injuries to muscles, blood vessels, and nerves contribute greatly to the difficulties of treatment and to the time required for healing and restoration of function. These fractures are often bilateral and are frequently accompanied by injuries to other parts of the body.

From the Louisville City Hospital and University of Louisville School of Medicine.
Presented in the Fracture Symposium, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

The flow of large numbers of these seriously injured patients into our hospitals has had a greater effect on the treatment of fractures in this country than anything since the World War. One of the outstanding developments in this field has been the introduction of numerous methods for skeletal control and fixation of fragments, by the insertion of steel pins in both proximal and distal fragments, and the incorporation of these pins in plaster encasement. This method was adopted at the Louisville City Hospital in 1933, and has been used since that time to the exclusion of all other operative measures. It is not indicated when adequate manual reduction and plaster fixation are possible. It is used only in those cases which we would have treated formerly by continuous traction or direct open reduction and internal fixation. In our city hospital service, which includes a disproportionate number of severe and complicated injuries, the double pin method is used in about half the cases. In private practice the proportion is smaller on account of

the generally less severe damage. The apparatus which we use is a simplified version of the ones previously described (1, 2), and has recently been modified by Dr. Edward B. Mersch, of the Louisville City Hospital staff. This apparatus provides adequate control and fixation of proximal and distal fragments, and gives adequate room for operation or fluoroscopic examination.

ROUTINE PROCEDURE

1. After careful clinical and x-ray examination and recovery from shock, local or spinal anesthesia is administered.

2. One-eighth inch steel pins are driven through the os calcis and through the tibia at the level of the tibial tubercle. If the fracture involves the upper end of the tibia, the proximal pin is inserted through the lower femur. Pins are inserted directly through the skin without incision and are driven through the bone with a hammer rather than drilled. The tight grip of the bone on the driven pin prevents motion which may lead to infection. It is important that the pins be driven only through the cancellous extremities of the bone, since driving pins through the hard cortical bone in the shaft may split the bone.

3. The limb is placed in the apparatus and the pins fixed in place. Traction is applied and reduction completed by mechanical manipulation under visual control with a right angle hand fluoroscope. This fluoroscope, which contains a 45 degree angle mirror, can be used in small spaces and at angles where a straight fluoroscope would be impractical. It also protects the operator from direct radiation.

4. After reduction, traction is reduced to allow firm end-to-end contact of fragments. Overtraction, by such powerful mechanical devices, may contribute to delayed union.

5. A non-padded plaster cast is applied from toes to groin as soon as the condition of the soft tissue warrants. This cast firmly incorporates both pins.

6. Ambulatory treatment is started after application of the cast. The cast and pins are removed at the end of about 8 weeks. A new cast may be applied at this time, as high as the tibial tubercle or the upper thigh, according to the site of fracture and the progress of union. This cast takes the place of a convalescent brace until unprotected weight bearing is safe.

7. Compound fractures are treated by thorough débridement, after fixation in the apparatus. Those débrided within 8 hours of the time of injury are usually closed primarily. Closure in layers is avoided and the skin only is closed. Interrupted sutures allow oozing of blood and serum from the wound. No drains are used. The wound is left exposed to air, without dressings. Older wounds are packed open with vaseline gauze after débridement. A prophylactic dose of gas and tetanus antitoxin is administered in all compound injuries. The extremity is left in the apparatus for observation and treatment of the wound until its condition permits the application of plaster.

From July 1, 1933, to June 1, 1938, 576 patients with fractures of 1 or both legs were admitted to Louisville City Hospital. Three hundred and eleven of these were recorded as due to automobile accidents; 55 died within 48 hours, of shock and associated injuries, such as intracranial damage. Two of these deaths were attributed to fat embolus. Thirty-six were transferred elsewhere after first aid treatment. The 485 remaining patients had 512 fractured legs. Three primary amputations were carried out for severe crushing injuries. Our reluctance to perform primary amputation may explain 3 amputations subsequently found necessary, and may have been a factor in the 5 subsequent deaths from gas infection. Of the 509 extremities treated, double pins were considered necessary in 259. The 250 remaining cases with less severe injuries were treated by traction and manipulative reduction followed by the application of non-padded casts and walking irons. The treatment of these cases was carried out almost entirely by the resident staff of the Louisville City Hospital under only moderately close supervision. Four hundred and sixty patients were followed for a long enough period to judge the results of treatment.

RESULTS

Of 171 simple fractures not requiring pins, 155 healed within 2½ months and 16 healed within 6 months. Of 16 simple fractures into joints not requiring pins, 12 healed in 4 months and 4 within 6 months.

In a group of 21 compound fractures not requiring pins, 20 healed within 6 months. One case of delayed union was treated by subcutaneous drilling and had good union at the end of 12 months. Four of 5 compound fractures into joints not requiring pins were healed in 5½ months. One developed osteomyelitis and required 2 years for recovery.

We had 101 simple fractures requiring pins, 95 of which healed within 4 months. There was 1 amputation in this group due to arterial thrombosis. Too early application of a cast to a poorly nourished extremity probably caused this thrombosis. Five cases showed no union at the end of

6 months. All were treated by subcutaneous drilling, which resulted in union in all cases. In a group of 16 simple fractures into joints requiring pins, 12 healed in 4½ months, while 4 required 7 months for restoration.

There were 130 compound fractures requiring pins. One hundred and five of these healed within 6½ months; 8 healed following persistent ambulatory treatment; 6 cases of delayed union, which were submitted to drilling, healed within 18 months. One other did not respond to drilling but healed following a sliding bone graft. There were 7 deaths in this group, 5 due to gas infection and 2 to late shock. There were 3 secondary amputations, 2 for defective blood supply and 1 for gas infection.

Double pins were used in a total of 259 fractures, that is, 518 pins were inserted. Complications due to these pins, which were noted or severe enough to require treatment, were as follows: There were one mild and one severe osteomyelitis; 8 infections of soft tissue, 2 of which had persistent draining sinuses.

COMPOUND FRACTURES

Recapitulation of the 156 compound fractures treated shows that débridement and vaseline gauze pack were used in 25. Thirteen of these wounds healed well. There were 2 gas infections with death and 1 amputation for defective blood supply. Osteomyelitis of mild degree occurred in 7. There were 2 deaths due to late shock.

Primary closure after débridement was carried out in 131 cases. Primary healing was obtained in 102. There were 11 mild and 4 severe soft tissue infections. Three of these patients developed gas infections which resulted in death. There were 8 cases of osteomyelitis. Three amputations were carried out, 1 for gas infection and 2 for sepsis with impaired circulation.

CONCLUSIONS

1. Double pin skeletal fixation was carried out in 259 of 509 fractures of the leg, to the exclusion of all other operative measures.

2. These cases were from a City Hospital service with a large proportion of severe bumper fractures, and treatment was carried out by the resident staff.

3. Complications due to the treatment, i.e., pin infections, have been lower than would have been expected in a similar series treated by direct operative reduction and internal fixation.

4. Thorough débridement and copious irrigation have been applied to compound fractures. Orr treatment has been reserved for old wounds; recent wounds have been closed primarily without drainage, with interrupted sutures to the skin only, avoiding the introduction of ties or sutures below the skin. This has proved to be a satisfactory procedure.

5. Subcutaneous drilling of fragments has been effective in cases of delayed union.

REFERENCES

1. GRISWOLD, R. A. Major fractures of the tibia and fibula. Surg., Gynec. & Obst., 1934, 58: 900–902.
2. Idem. Fracture of both bones of the leg. J. Am. M. Ass., 1935, 104: 35–38.

REPORT OF SYMPOSIUM ON METALLIC FIXATION IN FRACTURES

BOWMAN C. CROWELL, M.D., Chicago, Illinois

THE question of the open reduction of fractures with the use of metallic fixation was discussed at the meeting of the Fracture Committee of the American College of Surgeons held in New York, 1938.

In opening the meeting the chairman, Dr. Frederic W. Bancroft, stated that he felt that the Committee had the opportunity to do something constructive in the matter of operative fixation, with particular reference to the metals used for fixation. The paper for discussion was presented by Dr. Charles S. Venable, of San Antonio, Texas, and dealt with the electrolytic action of various metals in the tissues and its relation to osteosynthesis. Dr. Venable viewed this electrolytic action as being the controlling factor in osteosynthesis when metals were used. He stressed the fact that there had been a great deal of difficulty encountered in osteosynthesis by metallic fixation, with many serious complications and many inconsistencies in results. In keeping with this he felt that there was a wide difference of opinion on the part of the various investigators. He felt that many of the analyses of the studies had been defective because of the absence of biochemical examinations, and felt that use of metallic fixation was essentially to be considered in terms of metal corrosion concomitant with electrolytic action.

Dr. Venable then detailed a series of experimental findings. He showed definitely by these experimental findings that when 2 different metals were placed in bone and immersed in Ringer's solution, metallic corrosion due to electrolytic action occurred. He also stressed the fact that in a single piece of metal alloy of the type in which the components of the alloy acted as independent units in the compound, similar electrolysis between the various units with resulting corrosion occurred. He stated that such corrosion evidenced an electrolytic action which disturbed bone cells and bone growth and resulted in the loosening of both the plates and the screws.

Dr. Venable showed that vanadium steel, silver plated steel, nickel plated steel, and chromium plated steel, all showed some degree of corrosion in this set-up. He stated that when 2 different metals were used such corrosion invariably took place and the existence of difference of potential could always be shown, evidencing electrolytic activity. Chromium alloy steel, in his experiments, showed a similar action. Vitallium was the only metal in his series which remained practically inert under the same conditions as existed when the preceding metals were used. He followed these experiments by similar ones in the living animal in which actual contact with the metals was made with a wire connection through an outside galvanometer, demonstrating the existence of a current passing from one to the other except when vitallium was used. He demonstrated perfectly that of all the metals tested vitallium alone proved practically inert under the conditions of the experiment. He then showed a number of clinical cases in which vitallium was used with no evidence of interference of bone formation or of loosening of the structures; and also a case in which a Parham band was used in conjunction with vitallium fixation with resultant bone absorption in the vicinity of the Parham band.

His conclusions were: (1) That it is impossible for macroscopic, histological, or roentgenological studies to determine the reaction of bone to metal; (2) that such reaction can be demonstrated only by biochemical studies; (3) that when different metals are used the amount of electrical action depends upon the difference of potential of the metals used; (4) that in mixed metals or alloys in which the units of the alloy enjoy independent action a similar difference of potential with the creation of a battery action exists; (5) that appliances containing chromium are particularly troublesome by reason of concentration of electrolytically freed chromium in the liver; (6) alloys which are non-magnetic, entirely resistant to corrosion, and which possess sufficient tensile strength should be used for bone fixation; (7) experimentally, the alloy, vitallium, made of cobalt, chromium, and molybdenum is not magnetic and is the only metal known at this time which can be used with consistent results; and (8) electrical phenomena are the controlling factors in osteosynthesis with metals.

Presented before the annual meeting of the Fracture Committee of the American College of Surgeons, New York, February 18, 1938.

Following Dr. Venable's presentation Dr. Colin G. Fink, professor of electrometallurgy, Columbia University, discussed the presentation. He stated that as a lay person he assumed that the problem was divided into 2 parts, that of getting mechanically rigid fixation, and that of the behavior and nature of the metal itself. He emphasized the fact that there is always some solubility when metal is in contact with body fluids over a period of time. He felt that Dr. Venable's demonstration of vitallium showed that there was not enough solution of vitallium in contact with tissue fluids to create any appreciable electrolytic potential. He stated that his only hesitancy about the alloy was the fact that it was composed of 3 constituents and that under such circumstances it was difficult to reproduce the exact composition at will. Dr. Fink stated that if perfectly pure silver could be secured there should be no corrosion in the tissues, and felt that a silver coated steel might be an interesting possibility.

Dr. Fink's discussion was followed by the presentation of Mr. Frank, who represented the manufacturers of vitallium. He stated that vitallium had primarily been developed for use in dentistry, and had proved to be electrically inert in the mouth, and had been able to meet all the severe stresses put upon dental prosthesis. He stated that it had absolute resistance to corrosive influences. He also stated that the vitallium alloy used was a single phase alloy in which the fear of interreaction between the components was reduced to a minimum. He compared the corrosive resistance of various metals with that of vitallium and drew the same general conclusions that Dr. Venable had drawn. He stated that vitallium had a high degree of rigidity measured as the modulus of elasticity.

Dr. Philip Wilson introduced Captain Daniel J. Martin, of West Point, who 2 years previously had tested metals for this committee when they had been attempting to work out a suitable plate. He stated that he believed too much stress was being placed on the point of corrosion inside the body. He did not think that the problem of corrosion should be considered a problem of importance, but that the mechanical properties of the alloy used were much more important. He felt that the chromium-vanadium steel failed not because it was not suitable material to put into the body, but because the heat treatment given before use made it too hard; and sometimes it was cracked in the quenching operation, which accounted for both the corrosive activities and the breaking of plates and screws after insertion into the body. He stated that the stampings on the plates similarly introduced mechanical faults, and he felt that no pure metal would have the physical properties necessary, and that some kind of alloy was indicated.

Dr. Clay Ray Murray next discussed the problem. He stated that the service at the Presbyterian Hospital had investigated the whole question of plates and screws from the standpoint of clinical application. He believed that it was important to consider the purpose for which metallic fixation of the bones was used. If used merely to fix fragments of bone together, to be followed by fixation in plaster, the necessary physical qualities of the metal would be quite different from those required for patients in whom rigid fixation of the fragments sufficient to stand the strain of early, active mobilization without plaster fixation was the object.

He felt that there was no question about the existence of electrolytic action in the tissues. As a matter of fact the mere trauma of operation is sufficient to set up a difference in potential of as high as 100 millivolts between the injured tissue and the adjacent normal tissue. One of the problems for consideration is whether the plate intensifies or prolongs that reaction. In the studies at the Presbyterian Hospital, in which was used a system employing Corning glass Quin-Hydrone electrodes inserted directly into the tissues, he had become convinced that the degree of calcium deposition at the site of fracture was dependent upon the extent of ionization present in the tissues at the fracture site. So long as an acid hydrogen ion concentration existed at the fracture site no calcium deposition occurred. It was of interest that lack of rigid fixation produced acidity at the fracture site due to a mechanical inflammatory reaction regardless of the type of fixation. He had discontinued the use of vanadium steel not because of any reaction in the tissues sufficient to interfere with bone formation, although unquestionably reaction did occur, but because in his experiments vanadium steel was too hard to stand the stresses and strains placed upon it when used as the sole means of fixation under normal body strains. A bone in a living individual is to be considered as under constant vibratory stress due to alternations in muscle tone and to intermittent bending, and torsional and shearing strains due to normal muscle efforts. No tests, which depend upon the ability to bend a metal numerous times at right angles, reproduce the strain the metal is subject to when placed rigidly fixed across a fracture site. Dr. Murray with Captain Martin believed that within reasonable limits the mechanical factors implied

in the rigidity of fixation and the ability of the metals used to stand normal physiological strains were of far more importance than the possible electrolytical potential established by the metal in the tissues. This did not, of course, apply to the use of metals which produced marked electrolytic changes, or to the use of 2 different metals in the tissue. A vanadium steel plate, subjected to continuous vibratory stress of very small amplitudes for the period of a week, became so brittle that the steel could be snapped in the fingers. Clinically similar action had been evidenced by plates which had broken in the bone even after healing of the fracture by callus had been accomplished. Tests made with an 18 per cent chromium and 8 per cent stainless steel specially prepared had convinced him that the metal had, when properly treated, not sufficient electrical activity in the tissues to cause damage, nor did it have the proper physical characteristics to warrant its use under the conditions of resumption of active motion within a few days of operation without plaster fixation. To him this seemed important since he found that the cutting down of disability time by the early restoration of active function represented the chief advantage in most cases of the operative reduction of fractures.

He asked Dr. Hudack, who had carried out some experimental procedures, to present his evidence. Dr. Hudack stated that the metal used should have resistance to surface corrosion and resistance to fatigue failure. Vanadium steel under the vibratory stresses described had suffered intermolecular corrosion as the result of fatigue strain, making it liable to fracture. The same thing did not happen when a solid solution of the 3 phase high chromium low nickel steel was used. It was also found that stamping and casting both impaired the necessary physical qualities of the metal. In addition it was found that a non-abrasive polishing of the surface was necessary. He also stated that a minimum degree of corrosion was much less important than these physical qualities. Preceding the non-abrasive polishing of the surface a passivating of the surface by the use of an acid bath was indicated. Microscopic section of the tissues a year after the insertion of plates and screws constructed for him, *mechanically perfect, inserted so that rigid fixation was a fact*, showed bone trabeculæ still occupying the thread of the screw without evidence of decalcification or histological change.

A representative of the stainless steel (18 per cent chromium—8 per cent nickel) manufacturers stressed the buffering and passivating of the metal before insertion into tissues. She also stressed the fact that evidence of corrosion in specific solutions outside the body could hardly be considered as indicative of the extent of such action in the complicated tissue fluid set-up at the fracture site.

At the invitation of Dr. Philip Wilson, Dr. George W. Hawley presented a vitallium plate based on the angle iron used in steel buildings, one surface being attached to the bone and the other resting in a longitudinal slot previously cut in the bone at the site of the application of the plate. He stressed the fact that this type of plate might be of great benefit in getting rigid fixation.

Dr. William O'Neill Sherman, of Pittsburgh, stressed the point that he did not believe that animal experiments were of much value. He felt that the vanadium steel plate as used by him was effective mechanically if rigidly fixed, and could be depended upon to stand the strains to which it would be subject physiologically. He believed that no metal was capable of standing the vibration test which had been imposed on the vanadium steel by Dr. Murray and Dr. Hudack, and that although the specific stainless steel mentioned had done so in the experimental test, it could not be consistently expected to do so.

The results of the whole conference would seem to indicate that the 2 factors, first, the composition of the metallic fixation used, and second, the rigidity and adaptability of the fixation used to physical strains and stresses, probably represent the basis of a possible solution to the question of operative fixation.

It is evident that the question, whether or not operative fixation is to be followed by active mobilization or by fixation in plaster, has a great bearing on which of the 2 factors mentioned may be the most important consideration in any given case.

CONFERENCE ON TRAUMATIC SURGERY

THE MEDICAL CONTROL OF SILICOSIS AND TUBERCULO-SILICOSIS

LEROY U. GARDNER, M.D., Saranac Lake, New York

MEDICAL control of silicosis in the United States today is largely in the hands of industrial physicians experienced in the diagnosis of the particular forms of the disease produced in their respective plants. By means of pre-employment examinations these physicians have an accurate knowledge of the physical condition of each new workman entering the plant; from frequently repeated, periodic examinations they have an opportunity to observe the evolution of at least the early phases of reaction to inhaled dust. By studying the older employees, who worked in these same plants before the introduction of programs of dust prevention, these doctors have become familiar with the more advanced stages of these diseases; and they also have at their command accurate data upon the degree and character of atmospheric pollution in different parts of their plants. By correlating these data with their medical findings, they have drawn reasonably reliable conclusions as to the hazard from breathing dusts of varying silica content. Some of these conclusions are still tentative and may be altered in the light of subsequent experience and the introduction of improved methods of examination.

As a result of their individual observation in different plants certain principles have been formulated which now govern the medical control of silicosis and related conditions. Although variations in the anatomical form of the disease and in the degree of associated disability may be created by inhaling silica in various combinations with other mineral dusts, and by the diversity of processes producing dust in different plants, these general principles seem to be applicable to all industries.

Three of these observations are of fundamental importance: (1) The diagnosis of silicosis is based upon 3 factors: (a) evidence of disease in the lungs demonstrated in roentgenograms; (b) a history of exposure to silica dust, *adequate to produce such disease;* (c) a physical examination to determine the presence of infection and disability. (2) The major cause of disability is not the tissue reaction produced primarily by the inhaled dust, but pulmonary infection which so frequently accompanies such reaction. (3) The degree of disability is not proportional to the extent and severity of the anatomical changes observed in the roentgenogram. Disability can be measured only by observation and physical examination of the workman.

From the Saranac Laboratory for the Study of Tuberculosis.
Presented in the Symposium on Industrial Medicine and Traumatic Surgery, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

TYPES OF LESIONS

The pathological lesions of silicosis in pure form and silicosis with infection have been divided into 4 major categories. Since each type presents a different clinical picture and requires different administrative treatment, these 4 types will be discussed individually.

1. A pulmonary reaction characterized anatomically by accumulations of dust-filled phagocytes and proliferation of cellular connective tissue in the larger septa and trunks, and roentgenographically by exaggeration of the linear shadows chiefly cast by the blood vessels, may be due to a variety of causes. Such appearances may be a manifestation of beginning silicosis, in which case they may later progress to the stage of parenchymatous nodulation; but they may also be due to the inhalation of non-silicious dusts which produce only linear reactions without further progression. Furthermore, the roentgenographic appearances of certain chronic infections of the lungs and the pulmonary changes associated with cardiovascular disease of certain types may closely simulate the picture produced by dust. Only a thorough study of the individual and his occupational history can possibly reveal the cause in a particular case. The roentgenographic appearance of linear exaggeration is rarely associated with disability. When it is, other causes must be carefully excluded before attributing the clinical findings to the pulmonary condition. Since linear exaggeration in the pulmonary roentgenogram may be due

to so many causes, it is impossible to state whether associated tuberculosis or another infection in a particular individual is due to the underlying anatomical change. Among groups of persons employed only in industries creating highly silicious dusts, the incidence of pulmonary infection may be moderately increased in individuals showing linear exaggeration. However, the increase never approximates the percentage observed in persons with specific nodulation of silicosis.

It is generally customary to accept for employment in a dusty industry any applicant whose film reveals slight or moderate degrees of linear exaggeration. Men with very marked changes of this type, whose occupational history suggests considerable previous exposure to silica dust, will be rejected by many examiners. It is debatable whether this attitude is justified except in the case of young individuals under 30 or perhaps 35 years of age. In applicants over 40, who have already been exposed for 15 or 20 years, the condition is much less likely to progress, particularly in an industry where the engineering methods of dust control are effectively applied. The discovery of linear exaggeration upon periodic examination of persons already employed demands no action unless the condition is developing rapidly in young individuals. This rather rare occurrence is probably best met by transfer to another department of the plant. Otherwise no change in occupation is indicated; compensation rarely enters the picture owing to the lack of disability and consequent wage loss.

2. Dust reaction characterized anatomically by the formation of discrete fibrous nodules, not over 6 and usually not over 4 millimeters in diameter, uniformly distributed throughout all parts of both lungs and roentgenographically by the picture known as "nodulation" (discrete shadows of the above size and distribution) is most likely to have been caused by inhaling free silica. A history of adequate exposure to such dust, together with a physical examination usually establishes the diagnosis with reasonable certainty. Only a few rare fungus infections, certain tumors, and very unusual cases of cardiovascular disease produce similar patterns in the pulmonary roentgenogram. Discrete nodulation is uncommonly associated with sufficient disturbance of pulmonary function to impair the capacity for habitual work. In advanced cases, which are usually complicated by emphysema, dyspnea on exertion is a common symptom. The individual with generalized discrete nodulation is definitely more susceptible to tuberculous infection and to bronchopneumonia of other etiology than a normal subject. The same is not true for lobar pneumonia. Although this increased susceptibility to infection makes the silicotic workman a potential liability, he is usually capable of productive work until such infection develops.

Pre-employment examination often unjustly prevents persons with simple discrete nodulation but no disability from obtaining work. In periods of labor shortage, however, skilled workmen with such manifestations of silicosis have been accepted and have rendered efficient service. Provision in the compensation laws to relieve employers of full responsibility for any infection, which might develop subsequently, would overcome their natural reluctance to hire such men and would permit most silicotics to be self-supporting. In the periodic examination of persons already employed in a silica industry, the discovery of early, simple, discrete nodulation does not justify discharge. Significant degrees of disability will not be manifested in the absence of infection, and in industries with effective dust prevention programs the silicosis will progress with equal rapidity regardless of continued employment. Only the young individual, who has developed silicosis at an early age, need be transferred to another job because his naturally greater susceptibility to tuberculosis might be augmented by further exposure to silica dust. Perhaps the most important function of the periodic examination is the early detection of evidence of pulmonary infection. Such cases must be given the benefit of prompt treatment and removed from positions where they might endanger fellow workmen with silicosis. They will be considered in section 4.

3. Dust reactions, characterized anatomically by areas of massive, "conglomerate" fibrosis with or without an associated discrete nodulation, present the greatest problems in diagnosis and administration. The pathological anatomy of such lesions consists of large areas, often bilateral, composed of great numbers of nodules embedded in a matrix of diffuse fibrosis which more or less completely obliterate the normal pulmonary architecture. Other parts of the lungs usually exhibit small, discrete, isolated nodules but these may be absent. Almost invariably the so called "conglomerate" fibrosis is associated with well marked emphysema, often of the bullous type. The causation of such lesions is not well understood. Some of them are unquestionably due to low grade infections which produce no toxic symptoms for long periods of time; others, in the writer's opinion, are the result of excessive accumulations of silica dust in the scars of healed

infections. Since such lesions are most frequently discovered in persons exposed to mixtures of silica and other minerals, the latter may play an etiological rôle. Regardless of their cause all such lesions are complicated by emphysema and this reaction is responsible for the cardinal symptom of dyspnea.

The severity of the dyspnea limits the capacity for work and usually compels retirement. Many old employees, who suffer from this condition are permitted to perform light work about the plant, which they may prefer to retirement on pension. Discharge becomes obligatory only in cases where the massive fibrosis is due to associated tuberculosis, which has become active and is shedding tubercle bacilli in the sputum. The methods of detecting this outcome logically belong in the next category.

4. Tuberculosis is the most important infection of the lungs to be considered in the silicotic subject. Bronchopneumonias of other origin may present difficulties in diagnosis but, as they generally run a chronic course and produce results comparable to those provoked by the tubercle bacillus, they will not be discussed.

Tuberculosis associated with silicosis may manifest itself in typical form in which case it offers no particular problems of diagnosis or administration. The discovery of active or questionably active foci of this infection in pre-employment examination obviously disqualifies an applicant for work in a silica industry. Ample experience indicates that long-continued inhalation of silica dust may reactivate such latent foci and produce chronic disease. Apparently healed foci of tuberculosis offer greater problems. In young applicants, whose foci are more likely to be of recent origin, it is unwise to permit the risk of reactivation. Some authorities apply this dictum not only to apparently healed foci of reinfection in the pulmonary apices but even to the calcified foci of primary infection that generally occur in childhood. While most of the latter lesions are completely healed and sterile by the age of employability, a few cases of reactivation have been observed. In experimental animals reactivation has been proved possible in any focus still containing living tubercle bacilli. A reasonable policy would permit employment of all persons of mature age with roentgenographic evidence of small calcified primary foci. If the subject were young and his primary tubercle were large or exhibited any other suggestion of incomplete healing, he should be rejected, at least temporarily. In the periodic examination the discovery of a new case of typical tuberculosis in a silicotic subject demands the same procedure as in the general population, i.e. immediate treatment.

Unfortunately the majority of tuberculous complications in silicotic lungs are not typical and present serious problems in diagnosis. Such conditions fall in 2 categories, 1 an acute manifestation and the other characterized by unusual chronicity.

Acute tuberculosis is quite as rare in silicotic groups as it is elsewhere. Since the victims are prostrated by symptoms of intoxication, they would hardly be a problem in the pre-employment examination. If the periodic examination of a workman, whose films previously revealed generalized, discrete nodulation, discloses a marked increase in the size of the nodular shadows with loss of their ordinarily sharp definition, one should suspect infection. If in addition the film presents a new ill-defined but localized shadow, perhaps in the upper portion of the lung, the probability of tuberculous complication is even greater. Usually, if the man himself has not volunteered a complaint, questioning will reveal symptoms and he may even have some fever. Obviously he needs prompt hospitalization with the usual treatment. Such cases tend to run a rapid course and most of them terminate fatally within 6 to 12 months.

The chronic aspects of tuberculosis in the silicotic subject have already been mentioned in connection with the massive types of simple silicosis. The questions raised in section 3 remain to be discussed. If the localized lesion is due to some cause other than an active infection, it is classified as one of simple silicosis. If it results from an infection that is still active but encapsulated and latent, it should be classified as tuberculo-silicosis.[1] This is a new condition and not merely a superimposition of an element of infection upon a background of silicotic fibrosis. It apparently results from the simultaneous action of silica and relatively few tubercle bacilli barely able to survive in an environment of avascular scar tissue. It may produce no symptoms of intoxication and no bacilli in the sputum for many years because the investing scar tissue prevents absorption of toxic products and the excretion of tubercle bacilli. Late in life, however, the infectious element usually becomes dominant; symptoms of infection are manifested, bacilli reach the bronchi and are expectorated, and frequently the fibrous area breaks down to form a cavity.

[1]The writer has previously employed the term, "silico-tuberculosis," to describe the same condition. At a recent meeting of the Correspondence Committee on Silicosis of the International Labor Office it was urged that in conformity with South African usage the order be reversed. In compliance with this request for international uniformity in terminology the condition in the future will be referred to as "tuberculo-silicosis."

The industrial physician's problem in diagnosis is difficult. As long as the infection remains dormant the workman is not a menace to his fellows; he may not be seriously incapacitated, though more or less short of breath, and he may wish to continue at his job. It is probably just as well that he should, for no form of treatment up to the present time has cured such a disease so far advanced. If the employee's temperament is such that he is happier at home, he should be retired on compensation but permitted to perform light jobs.

If he is kept under observation, it is not always easy to determine when his tuberculo-silicotic lesion is about to break down and become a menace to other employees. Systematic records of body weight are kept; a progressive loss suggests the need for further investigation. Repeated roentgenograms may reveal a change in the size or the character of the localized lesion and perhaps evidence of extension in the surrounding lung. Examination of the sputum for tubercle bacilli requires patience as many negative reports must be anticipated; persistence will usually yield positive results. Guinea pig inoculation or culture are preferable to direct methods of examination as the number of organisms is small when they first make their appearance.

At the first indication of clinical or bacteriological activity the workman with tuberculosilicosis should be removed from contact with other silicotics. In some plants special, isolated jobs, involving little or no physical effort, have been created for them. Hospitalization and any of the forms of treatment applicable to uncomplicated chronic tuberculosis have had little effect upon this condition. Intelligent cooperation with a minimum of physical effort may prolong life but it cannot cure the disease. Since this is usually most difficult to obtain from men of this class, there is need for research upon new means of therapy. Today one can only hope that modern programs of dust prevention will preclude the development of tuberculo-silicosis in the new generation of workmen.

From the foregoing discussion it is obvious that uncomplicated silicosis usually produces too little disability to disqualify a workman for his habitual occupation. The supervention of tuberculosis or other infections of the lungs are largely responsible for decreased capacity to work and are the ultimate cause of death in many silicotic subjects. Therefore, it should be the major objective of the industrial physician to protect his silicotic charges from contact with the tubercle bacillus. The methods which he employs inside of the plant have already been indicated but his responsibility does not end here. He must also extend his supervision into the home and the community at large. By cooperation with the public health authorities, programs of case findings and education should be encouraged. Every hospitalized case of open tuberculosis in an employee reduces the possibility of a disabling infection in an industrial physician's plant.

METHODS OF INVESTIGATION OF OCCUPATIONAL SKIN DISEASES

LOUIS SCHWARTZ, M.D., New York, New York

In order to investigate intelligently the cause of occupational dermatoses, one must have at least a sufficient knowledge of dermatology to distinguish contact dermatitis from such ordinary skin diseases as psoriasis, impetigo, urticaria, ptyriasis rosea, etc. In addition, one should also have a fair knowledge of chemistry. The actual investigations in factories will give one the knowledge of industrial processes which is also an essential requirement.

Before we can hope for success in finding out the cause of a particular outbreak of occupational dermatitis, we must have the experience and knowledge gained by studies of the normal skin hazards and the normal incidence of occupational dermatoses in the basic industries. Such studies not only acquaint us with the irritating properties of various chemicals and compounds, but often lead to the discovery of health hazards not previously reported. It was in the course of such routine studies that we first noted the health hazards connected with the manufacture and use of certain chlorinated hydrocarbons and certain synthetic resins.

The basic industries are selected for routine studies, because they manufacture the chemicals used in all other factories, and their workmen are subject to the hazards of contact with these chemicals. We also make it a practice to scan the reports of occupational dermatoses which are submitted to the Public Health Service by the Compensation Boards of the various states, and we note if there is any unusual occurrence of occupational dermatoses in any one factory. If there is, we investigate its cause.

To gain entrance into factories to make our studies, we first awaken the interest of the owners or management to the importance of our work. This is done by means of letters and interviews in which we assure them that our studies are conducted in such a manner as not to alarm the workers or to inconvenience the routine of the factory; and that the results of our investigations will in no way hurt their business, but, on the contrary, will help to lessen the health hazards among their workers. After such interviews permission to make the investigations have always been granted.

In proceeding with an investigation, the first step is to discuss with the plant superintendent the occurrence of occupational diseases, especially those of the skin, which to his knowledge had occurred in the factory, to obtain from him a list of the raw materials used in the factory and of the products manufactured. The next step is to consult with the plant physician, if there is one, or with the nurse or first aid attendant, concerning the chief infections or diseases treated in the dispensary, and to obtain from them a little better conception of the incidence of skin diseases than was obtained perhaps from the superintendent. The medical records, if any have been kept, are then examined regarding the number of cases of skin lesions treated, the departments in which the patients worked, and the causes given for their occurrence. This procedure often yields a clue as to what part of the factory has the greatest skin hazards. It is also well at this time to request that such of the workers, who have had occupational skin diseases or who are known to be affected at the present time, be called into the dispensary to be questioned and examined. This enables us to check and evaluate the criteria used by the plant physician in making a diagnosis of occupational dermatitis.

We then request the superintendent to appoint someone familiar with all the industrial processes in the factory to escort us through the plant. In many instances he himself, together with the plant physician, accompanies us in our inspection. We begin at the point where the raw materials come in and follow them through the plant until the finished product is ready for shipment. In each department visited we first interview the foreman, asking him if he knows of any workers who have now, or ever have had skin diseases, and what in his opinion caused these diseases. We then go through the department and have the manufacturing process explained to us. We examine the hands and faces of the workers for skin lesions, at the same time taking note of their work clothes, whether they are clean or dirty, and whether protective clothing in the form of gloves, aprons, boots, respirators, etc., are worn. We

From the United States Public Health Service.

Presented in the Symposium on Industrial Medicine and Traumatic Surgery, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

note the cleanliness of the work room, whether there are any safeguards on the apparatus, such as ventilating hoods, etc., and ask each worker if he now has or ever has had any skin diseases. The names of workers, who are found to be affected with skin lesions or who state that they have been affected at some time or other, are taken, and at the end of the day's inspection these workers are summoned to the dispensary and examined further.

The primary inspection of the men at work takes but a short time—not over half a minute for each man. The same procedure is followed in every department, and notes concerning the industrial processes and hazards are taken. At the end of the day's inspection, usually an hour or so before the end of the day's shift, we go to the first aid room and send for the workers found during our inspection to be affected with skin diseases. Such workers are examined one at a time with only the plant physician, nurse, or first aid attendant present. The worker is required to disrobe completely and his body is examined for the presence of skin diseases. It is important to strip the patient, because often an important clue to the diagnosis is revealed which might otherwise be overlooked.

A card record is made of the patient, noting the name, sex, age, color, and a detailed description of the worker's occupation, giving the chemicals with which he comes in contact. The date of entering on his present occupation is noted, as is also a history of his previous occupations. A record is made of previous skin diseases and of any allergic history; a detailed account of the present skin diseases is taken, putting down the date of onset and the symptoms; a written description of the skin lesions and their location is made on the card; the patch tests, if any are performed, are also described, giving the names of the chemicals applied as patches, the length of time they are allowed to remain on the skin, and the resultant reactions. Based on this data the diagnosis is made and the actual skin irritant, if found, is named. Under the heading, "Remarks," we record complicating skin lesions and the treatment advised.

CRITERIA FOR DIAGNOSIS

The following criteria are used in making a diagnosis of occupational dermatoses:

1. *History.* This should bring out the fact that the dermatitis was not present before the patient entered on his present occupation, and that it developed during a period of industrial exposure or after a lapse of a reasonable period since the cessation of exposure.

2. *Site of eruption.* The eruptions must have begun first on the exposed parts, usually the hands, fingers and forearms, if the offending material is a solid, or a liquid, and on the face and neck, if the offending material is a vapor. However, in the case of irritant dusts, which may penetrate the clothing, the covered parts of the body may be affected first, especially if the clothing is not frequently changed. Sometimes the points of friction, such as the wrists where the ends of the gloves and sleeves rub, or the belt line where the belt or the top of the trousers cause friction, are the first affected.

3. *Characteristic appearance of lesions.* An acute industrial dermatitis begins as an erythema followed by papules, vesicles, and crusts, no matter what the irritant may be. It must be remembered, however, that there are a few classes of industrial irritants which produce more or less characteristic lesions on certain parts of the body, such as paronychia which is a common lesion among fruit and vegetable canners; acnes are common lesions caused by chlorinated waxes, petroleum oils, and coal tar; folliculitis and boils are often produced by dirty clothes and oil; and keratoses and malignant growths are caused by coal tar, certain petroleum, and arsenic.

Patch tests are an important diagnostic procedure, but they must be performed by someone familiar with the technique and who will not patch with primary irritants, otherwise they may lead to wrong conclusions. Before patch tests are performed on the workers, the object of performing them must be explained to them and their consent obtained, otherwise legal complications may develop.

Differential diagnosis is often difficult, but a rule that applies in many instances is that dermatitis, due to occupation, tends to get well when the patient is removed from his work, and recurs after the patient goes back to his same job.

When a number of factories manufacturing the same products have been examined, a fair idea of skin hazards in that particular industry is obtained. The knowledge and experience gained by routine studies of industrial processes and skin hazards in basic industries prepare us to undertake intelligently the investigation of the causes of outbreaks of occupational dermatoses. The requests for such investigations come from insurance companies, the managements of factories, and labor unions. Such outbreaks of occupational dermatoses usually occur when new chemicals are introduced, or when new manufacturing processes are being installed, or when there is some change made in old manufacturing processes.

While outbreaks of occupational dermatoses usually occur in only one department of a factory, it is necessary to study not only that one department, but the whole process of manufacture, or at least all of the processes which precede the one in which the outbreak occurred. We should study the sickness records of the plant for at least 1 year previous to the outbreak, in order to determine whether the outbreak occurred suddenly, or whether there was a gradual increase in the number of cases of dermatitis, and whether there was any connection between a sudden increase in the incidence and the use of new chemicals, new processes, or changes of old processes in the factory. Detailed inquiries should be made of the superintendent, the foreman, and the workers as to changes in manufacturing processes and the introduction of new chemicals preceding the outbreak of dermatitis.

Patch tests should be performed with all of the materials handled by the affected workers in an effort to track down the offending substance. In some instances the management purchases, under trade names from other concerns, the chemicals which they use and do not know their composition. It is necessary in these cases to trace the chemicals to their original source of manufacture and thus determine what they really are.

By way of illustrating how such outbreaks of dermatitis are studied, I will outline a few actual investigations which we made.

SPECIFIC INVESTIGATIONS

CASE 1. We were requested to investigate an outbreak of dermatitis in a cotton mill. It was found that the lesions occurred only among those workers whose forearms came in contact with new heddle frames in the weaving machines. The skin of the forearms touched by the heddle frames was first affected. The frames were made of spruce and were painted with a yellow, waxy varnish. Patch tests with the varnish scraped off the frames gave positive reactions, while patch tests with the wood itself gave negative results. Removing the varnish from the heddle frames checked the occurrence of dermatitis. This definitely established the fact that the varnish on the new heddle frames was the cause of the dermatitis.

Wanting to ascertain what in the varnish caused the dermatitis, we visited the manufacturer of the frames. There it was found that the varnish on these frames was purchased from a different paint factory than was the varnish which had previously been used and which had caused no dermatitis. The new varnish was introduced because it produced a smoother and a more waxy finish on the heddle frames. It was learned that some of the workers in the heddle frame factory, who were engaged in applying the new varnish, also contracted dermatitis. Letters to the other cotton mills, which had purchased the same new heddle frames, brought out the fact that cases of dermatitis had occurred also among their workers since the installation of the new frames. The makers of the varnish were then visited and the ingredients of the varnish obtained. These were taken back to the first cotton mill, reporting the outbreak, and patch tests were performed with all of the ingredients in the varnish on those workers who had suffered with dermatitis. It was found that chlorinated ceresin, a wax, was the chief irritant. Patch tests performed in other cotton mills confirmed the results obtained in the first mill. The chlorinated ceresin produced a smoother, waxy finish to the varnish, but under the atmospheric conditions, usually prevailing in cotton mills, the workers perspire freely and the perspiration, coming in contact with the wax, caused the formation of hydrochloric acid which was the actual cause of the dermatitis.

While patch tests are a great help in determining the causes of occupational dermatitis, it is not always possible to use them and we must sometimes devise other methods of approach. The following is an example of this:

CASE 2. An outbreak of dermatitis among cable splicers occurred in Chicago and in New York City simultaneously and in no other place, although the process of cable splicing is the same in all parts of the United States. After several unsatisfactory attempts by others at determining the actual cause of this outbreak, the telephone company referred the problem to the Public Health Service.

The workers affected had been patch tested by previous investigators and at first refused to submit to any more such tests. Therefore, we decided to divide the operation of cable splicing into 7 stages and to have the workers, who had been affected and who were now well, work a number of days on each stage then rest a few days before taking up the succeeding stage. In this way, we hoped to find out at what operation in cable splicing the dermatitis actually occurred.

It was found that the dermatitis occurred during the operation of "boiling out" the green and blue, paper-wrapped wires in the cables. The "boiling out" was done with a mixture of paraffin and mineral oil, and was done for the purpose of removing all moisture from the wires. The dyes used on the green and blue papers were malachite green and methyl violet. Although some of the stages of operation consisted of "boiling out" other colored wires with this mixture, no dermatitis occurred from splicing wires dyed any other color, nor did it occur from the "boiling-out" mixture itself. Patch tests performed with strong concentrations of the two dyes produced dermatitis in some of the workers. By the time that we had reached this stage of our study the workers had become so interested that they consented to our patch testing experiments.

Further experiments showed that in the process of "boiling out" the dyes were partially decomposed, and that the decomposition products were dissolved in the "boiling out" compound. The "boiling-out" compound was used over and over again, and in this way it contained a high percentage of decomposition products which were carried off in the fumes and irritated the skin of hypersensitive workers. The reason that the outbreak occurred at that particular time in Chicago was that there was a large amount of cable splicing being done for the Chicago Fair and the workers were unusually exposed to the fumes of the "boiling-out" compounds; while in New York, at about the same time, new cables larger than any that had been laid before were being installed and this entailed an unusual amount of cable splicing. As a result of these experiments new dyes were satisfactorily substituted for the old dyes in the manufacture of telephone cables.

CASE 3. Recently we were requested by an insurance company to investigate dermatitis occurring among workers in a factory manufacturing conduits made of paper

impregnated with coal tar pitch. Men working inside the factory were not affected but those working in the yard, where the finished conduits were stored, suffered considerably with dermatitis. Previous investigations resulted in no satisfactory explanation. A visit to the factory was made and on examination of the workers brought out the following facts:

All the workers exposed to the fumes and dust of the coal tar pitch, whether in the yard or inside the plant, had a marked melanosis. The workers in the yard suffered with dermatitis, especially on bright days, similar to a severe sunburn. The workers inside the factory stated that they, too, suffered more from sunburn on their days off from work than those employed elsewhere. Patch tests performed with coal tar pitch dust gave no reactions upon removal of the patch, but upon exposure of the patch area to sunlight there developed a marked sunburn. This showed that exposure to coal tar pitch sensitized the skin to light. Examinations of workers in other factories making conduits, where there was an exposure to coal tar products, revealed the same conditions. This was the first time that occupational photosensitivity was reported in America. Effective preventive measures were devised.

Because of the experience we have gained in making studies of industrial processes and the skin hazards connected with them, we are often called upon to investigate the causes of outbreaks of dermatitis occurring among the users of manufactured goods. The following will illustrate this:

CASE 4. A certain manufacturer of wrist-watches decided to use jet black, sweat-proof straps on his products. He ordered such straps from a leather strapmaker. After about 100,000 of these straps had been sold to stores, complaints and law suits began to come in because of dermatitis on the wrists of the wearers of these watches, which had been caused by the leather straps. The straps were sent by the watchmaker to a leather research institute and to a well known dermatologist to determine if they contained a skin irritant. Reports from both were negative. Before contesting the suits for damages, however, someone in the factory suggested that a number of the workers be asked to wear the straps as an experiment to see if any of them would develop dermatitis. Accordingly, 50 workers volunteered and were given the straps to wear and in a few days, 6 of them had developed a dermatitis of the wrists. The Public Health Service was then requested to investigate.

We visited the manufacturer of the straps and learned from him the source of the leather and of the dyes. We obtained samples and patch tested the workers who had worn the wrist watch straps with the undyed leather, the dyed leather, and with each of the chemicals used in the dyes. Positive reactions were obtained only from the dyed leather and from one of the dyes used in the dye mixture. This dye is known as butter yellow and has the chemical name of amido-azo-toluene-hydrochloride, and had never before been reported as a skin irritant. In fact, it was thought to be so innocuous that it had been used to color some edible fats. We found that the yellow dye was mixed with the black dye (nigrosine) in order to give the straps a jet-black color, instead of the blue-black color imparted to the straps if only nigrosine was used. Elimination of butter yellow from the dye mixture stopped the dermatitis caused by the wrist-watch straps.

We have had similar experiences with fabrics, paints, and cosmetics.

These are in brief the methods of investigation which we adopt in studying the causes of occupational and other forms of contact dermatitis. All of the investigations and problems of contact dermatitis are interesting, instructive, and fascinating, and some of them will tax the ingenuity of clever chemists, allergists, and dermatologists.

THE DIAGNOSIS AND THERAPY OF SO CALLED POSTTRAUMATIC NEUROSIS FOLLOWING CRANIOCEREBRAL INJURIES

DONALD MUNRO, M.D., F.A.C.S., Boston, Massachusetts

POSTTRAUMATIC neurosis, posttraumatic state, compensation neurosis, postconcussional state or neurosis, litigation neurosis, traumatic hysteria and malingering are all common and interchangeable terms. They are used to describe a group of symptoms which pester patients, doctors, insurance companies, and law courts and which develop after the patient, who has received any craniocerebral injury, has left the hospital or its equivalent. They imply conscious or unconscious attempts on the part of the victim to prolong unduly his period of invalidism and suggest a non-organic rather than an organic basis for his complaints. There have been, are and doubtless always will be individuals, who, after being hurt, give false testimony, and intentionally magnify minor injuries in order to obtain more money or other compensation than they are justly entitled to.

However, it is neither fair nor correct to conclude on that account, that all patients who have had head injuries in the past, and who, at some later date, complain of disabling symptoms, that cannot be shown by ordinary tests to be due to objective changes, should be classified with this unsavory minority. For example, LeFever and Secrest have shown that of 100 patients injured in industry and later proved to have objective signs of brain abnormalities 71 per cent had complained at first chiefly of headaches, 64 per cent of dizziness, and 43 per cent of tinnitus. The usual tendency of the medical profession to avoid the middle ground of reason and to take the attitude that such individuals are either the blackest sinners or the most spotless saints, justifies a consideration of the diagnostic and therapeutic possibilities of this problem. Only those patients, who continue to complain of symptoms referable to the head after they have been active a few weeks, are included.

DIAGNOSIS

When a physician is confronted with the necessity of making a diagnosis of a man who attributes headaches, inability to work, lassitude, dizziness, and the like to an antecedent accident, it is obviously of the first importance to be sure that he did, in fact, injure his head as he claims. To do this, it is only necessary to demonstrate a period of unconsciousness or its lay equivalent, and/or a period of severe headaches immediately or shortly after the accident. Confirmation may be had by scars on the scalp and, of course, by x-ray evidence of bone damage of appropriate age. The usual and best evidence for or against this claim will be historical, however. In collecting it, the doctor should stay away from the legal or controversial aspects and content himself with obtaining those facts which can be verified by associated objective evidence. He should never accept the patient's own story without such confirmation as is obtainable from a description, or a lack of it, of the details of the periods immediately preceding and following the accident as well as those of the accident itself. These can and should be checked by independent witnesses or by the demonstration of such incontrovertible facts as the state of the weather, the road, the job, and the like.

Having satisfied himself that his patient has actually or probably been the recipient of a craniocerebral injury, the physician is justified in concluding that the symptoms about which the complaint is being made may be due, among other things, to the late effects of this damage. However, this conclusion cannot be final until other possible causes have been ruled out. The patient may, for example, have had an intercurrent disease, the presence of which is unknown to him, and which has no relationship whatever to the head injury, but which is actually producing symptoms that mimic those commonly seen as some of the late results of the previous accident. Even should this be considered a far-fetched possibility, the physician still must learn whether or not there is present evidence of continuing cerebral or cranial pathology. To get all this data, the patient who would learn the cause of his posttraumatic syndrome or who would be relieved of his symptoms must submit to hospitalization.

Presented in the Symposium on Industrial Medicine and Traumatic Surgery, before the Clinical Congress of the American College of Surgeons, New York, October 17–21, 1938.

Requisite information such as here outlined cannot be obtained in an office under any conditions; and a physician will do much better if he refuse to give any opinion, whether to patient, insurance company, or lawyer, until he is permitted to acquire the facts he needs in the proper way. Indeed, he should refuse to have anything to do with the case under any other circumstances.

Preparatory to a more intelligent estimation of the data that is to be acquired, and after the patient has been hospitalized, it is well to get what details one can relative to the treatment given at the time of the accident. This must, of necessity, have considerable bearing on the occurrence of late symptoms. If we predicate, for example, 2 individuals neither 1 of whom had any significant demonstrable symptoms during the acute stages, but who had been hurt in exactly the same way and to the same degree, and in whom a mild contusion and edema of the brain represented the underlying pathology, it should be obvious that the patient, whose increased intracranial pressure had gone untreated, would and should have greater permanent cellular destruction in his brain. If both these men happened to be "compensation cases" and complained of an inability to work 3 months after the injury, or had "posttraumatic" or "compensation neurosis," or were accused of "malingering," an organic lesion which was compensable could unquestionably be ascribed to the 1 who received improper or no treatment; while the other, who had received proper and adequate therapy, should be regarded with suspicion. Yet, the late symptoms are present in the first patient, in part at least, because of his doctor's failure to base his diagnosis on demonstrated pathology, and because of his belief that a lumbar puncture wasn't necessary since the patient didn't complain. It is this same fundamental inexactitude which leads to a diagnosis later of "postconcussional neurosis," when the patient's original injury was a lacerated brain, and despite the fact that concussion, by definition, is a self-limited disease and can have no aftermath. Thus, there should be available in every late case of craniocerebral injury, data as to earlier increased or decreased intracranial pressure, as to the presence of blood in the cerebrospinal fluid, reports of ordinary x-ray studies, a description of the pathology found in the course of any exploratory operation that was done, records of blood pressure changes, an enumeration of the number and notation as to the extent of any scalp wounds, and the involvement of air sinuses or arterial grooves in fracture lines. These facts will confirm or deny the probability of a head injury as deduced from the history, and will serve to annotate and help in the interpretation of the physical signs collected during this later hospitalization.

At this late date after the accident, the doctor's further aim should be to get a complete picture of the patient's present physical condition. The picture should be based chiefly, however, on an objective demonstration of facts. A physical examination, repeated neurological examinations, necessary mental tests, tests of the special senses, study of the blood and urine, and an estimation of the efficiency of the kidneys, must all be included. Lumbar puncture with a demonstration of the intracranial pressure, and chemical, serological, and cytological examinations of the cerebrospinal fluid are absolutely essential. An adequate x-ray examination should visualize the bony structures that come under suspicion. Such a procedure is the minimum that permits an inferential opinion as to the physical relationship between the accident in the past and the subject's symptomatology of the present. If the general studies are negative, it can be concluded that no intercurrent disease, previously unrecognized, is causing the symptoms which bring the patient to the doctor at that time. The special examinations should eliminate associated mental disease, arteriosclerosis, syphilis, multiple sclerosis, syringomyelia, pernicious anemia, and the like. The lumbar puncture and cerebrospinal fluid studies will rule out an expanding intracranial lesion, and the x-ray a previously unnoticed bone injury.

TREATMENT

If, by these diagnostic methods, the surgeon can show that the patient did, in fact, sustain a craniocerebral injury as he alleges, and that at the time of this later examination there is objective evidence of craniocerebral pathology, the indicated therapy should be provided without further delay. If there is objective evidence of cranial or intracranial abnormality, such treatment will of necessity be operative. A decompression will be required for a high intracranial pressure, depressed fractures should be elevated, cortical abscesses must be drained, and appropriate steps taken to correct such unusual conditions as traumatic arteriovenous aneurysm, the presence of bilateral, subtemporal decompressions, and the like. In addition, measures to improve the patient's general condition and psychological reactions should be initiated. For the first, a program of graduated, increasingly severe exercise interspersed with judicious periods of rest will be found most useful. The patient should be made the sole judge of the rate of increase. This

will deprive him of the use of any alibi for a failure to improve, that is based on the doctor's directions. Such a requirement will also set the stage for his psychological rehabilitation, the chief essential of which is to force him to assume full responsibility for all his actions. Thus, he will govern the speed with which he recovers and is able to return to his normal way of life, insofar as his permanent anatomical disabilities will permit him. Necessary adjuncts to this regimen are that he shall not see his doctor except at infrequent intervals; that his return to work shall, if possible, await his own request; and, that when he does return, he shall be started in on a job that does not require the use of his full physical capacity, even if this means a shift in work or temporary, half, or part-time employment.

Unfortunately, only a minority of patients that have had craniocerebral injuries suffer at this later date from organic abnormalities that have been missed previously and that can be demonstrated objectively. Usually, all objective tests are entirely normal and all symptoms exclusively subjective. All that the doctor has learned from his study of the patient is that at some designated time in the past, he did sustain a head injury and that now he shows no objective evidence of disease or injury. If the patient or those concerned with his welfare want more diagnostic data, he must accept the necessity of undergoing further, more complicated diagnostic procedures. These, because they carry a minimal but inescapable risk, cannot be forced upon him. If he elects not to take this further step, the doctor can do no more than inform him that at that time no objective evidence of disease or injury can be elicited as a cause for his subjective complaints. Hence, his symptoms may be due to neurosis, malingering, a subdural hematoma, cerebral atrophy, or psychotic maladjustment, and, because no certain differentiation can be made without further studies, no reliable advice as to treatment nor statement as to the future can be given. Such an opinion, being based upon demonstrable facts, can be supported in the face of hostile argument where traumatic neurosis and its synonyms will let the doctor down because of its vagueness and the implications of malingering that inevitably accompany it.

SUPPLEMENTARY DIAGNOSTIC PROCEDURES

If the patient or those responsible for him elect to go further in their efforts to rid the patient of his symptomatology, there are 2 supplementary procedures that are open to him. Both have a slight but inescapable risk and, therefore, cannot be carried out without his specific consent. This permission should be written and should be used only after the doctor has satisfied himself that the patient, his family, and any other interested parties fully understand that this further investigation carries no actual or implied promise of relief and that it is essentially and primarily a diagnostic procedure. As such, it will only indicate what further methods, if any, can be used to promote relief.

The first of these procedures is encephalography. A discussion of its technique and limitations cannot be undertaken here. Suffice it to say that in my clinic encephalography has demonstrated cortical atrophy with a high degree of accuracy, solid subdural hematomas sufficiently often to be a valuable adjunct in their diagnosis, (6) and fluid subdural hematomas and "encysted fluid" not at all. None of these conditions need be accompanied by any objective changes that would necessarily be demonstrable by any of the procedures discussed above. Encephalography has had no value as a method of treating the symptoms of the posttraumatic syndrome. While I have used it at times for this purpose, usually accompanied by suggestion, I do not believe that it is as efficient or reliable as other and more classical varieties of psychotherapy.

The other supplementary diagnostic procedure is exploratory trephination (3, 4, 6). This procedure offers the final opportunity to arrive at the cause of these late symptoms. While its ultimate object is to visualize a part of the cortex of both cerebral hemispheres, its chief and almost exclusive use is to determine whether or not a subdural hematoma is present and acting as the probable cause of the symptoms. This possibility is not so remote as might be imagined. Reference to Figure 1 will demonstrate that subdural hematomas are present in about 1 out of every 5 cases of craniocerebral injury that are hospitalized at the time of the causative accident. The figures are reliable having been verified in each case by operation or autopsy. When it is further borne in mind that the probability of diagnosing and treating subdural hematomas is extremely small, in non-hospitalized patients and in patients that are cared for in the smaller general hospitals during their period of acute illness, it must be apparent that previously unrecognized subdural clots will be even more common among those patients who come in complaining of late symptoms. No figures are available relative to this later occurrence rate, but it may well be that every other one of such patients will eventually prove to be suffering from the more

TABLE I.

	Occurrence per cent
Non-operable cases	63.0
Concussion	.9
Edema and congestion	18.2
Contusion	25.7
Laceration	17.3
Operable cases	36.9
Extradural hematomas	3.1
Depressed fractures	4.5
Compound fractures	11.3
Subdural hematomas	17.8

chronic forms of this condition. My experience leads me to this conclusion because in dealing with 330 hospitalized subdural hematoma suspects, there were only 62 or a little under 2 per cent of the explorations that were negative. Patients who have subjective symptoms long after their injury and who also harbor subdural hematomas, have the fluid rather than the solid variety (5). Except as a guess, it is impossible to diagnose this type of clot by any means other than exploratory trephination. This is well illustrated by the following characteristic case.

A twenty-year old college student was knocked unconscious playing football while a freshman. During the following 2 years he was removed from college, sent back to school, had a diagnosis of, and was bled for polycythemia, was next considered to be a brain tumor suspect, after which he moved to Chicago and was told he was hysterical. He then returned to New York where he had a negative encephalogram made and was sent to a well-known sanatorium. It was decided at this latter place that he had neither hysteria nor a psychosis. Following this, he was given pituitary extract as a possible pituitary tumor case, had another encephalogram made in Chicago and then had his appendix removed. Despite all this, he still had his headaches. He returned to college for 3 months but had to leave. I saw him at that time. He had no objective signs of central nervous system disease but was offered exploration and accepted. A fluid subdural hematoma was found and drained. His headaches and other symptoms were relieved by the time of his discharge from the hospital. He returned to college in 2 months and rejoined his original class. During the 4 succeeding years he graduated with honors, started in business and had no return of any symptoms whatsoever.

Since it is primarily diagnostic, the exploratory trephination need not be limited to subdural hematoma suspects. It may be legitimately used to verify other diagnoses such as cortical atrophy or scars or widespread arachnoidal adhesions. It will have a negative value also. This was well illustrated within my own experience by 2 instances.

In one, a patient was suspected of having been the victim of an automobile accident but proved at exploration to have no appropriate cerebral pathology. Further investigation, initiated as the result of this operation, demonstrated that he was suffering from acute bromidism and had never been in an accident. In the other case, compensation was about to be paid for a hemiplegia alleged to have been induced while the patient was at work, and as the result of an admitted injury that he had sustained 1 week previous to the onset of the paralysis. Exploration to verify the presence of a subdural clot demonstrated that he had had an arteriosclerotic thrombosis of one middle cerebral artery and that that was the cause of the hemiplegia which was entirely unconnected with the injury.

When a subdural hematoma is found by this means, this same exploratory procedure can be used as a therapeutic measure. If the hematoma is, as usual, fluid, it can be adequately drained and removed through only one transtemporal trephination. With this in mind, the diagnostic operation should be started by trephining on the side opposite to the speech cortex. If this should prove negative, the other side can be done.

Although invariably initiated as an exploratory diagnostic procedure, I have been able to make therapeutic use of this operation in 47 instances. All the patients had fluid subdural hematomas, all except 2 have been followed to date for periods varying from 1 month to 6 years (Table II) and all came under my observation for relief of symptoms that had persisted a month or more after they had been discharged from medical care administered for their original injury. Thirty-three of these 45 cases were relieved of all symptoms and enabled to return to their normal life and occupations following the drainage of their hematomas. A study of Tables II and III will give the details of the successes and failures.

In general, it can be said that in such patients: (1) The type of occupation, kind of accident, and length of the follow-up after the first 2 postoperative years are of little significance in making the diagnosis or the prognosis. (2) The successful cases averaged 4 years younger than the failures. (3) The large majority of failures will be apparent after the first postoperative year. (4) The shorter the interval between the receipt of the blow and the removal of the hematoma, the better the result. In this series, the number of failures was approximately 20 per cent greater than the successes at the end of the first postoperative year, 12 per cent at the end of the third, and 19 per cent at the end of the sixth year. (5) Finally, and most important of all, only 33⅓ per cent of the successes as opposed to 83 per cent of the failures showed objective evidence of the presence of central nervous system disease previous to operation and in addition to the subjective symptoms.

Unfortunately, no figures are available as to the number of patients studied on account of the same complaints but who refused exploratory

TABLE II.

Interval between accident and operation	Successes	Failures
1–2 mos.	4	
2–4 mos.	4	
4–6 mos.	4	
6½ mos.	1	
7 mos.		1
8 mos.	3	
9 mos.	2	
1 yr.	2	3
1½ yrs.	1	1
2 yrs.	3	1
2½ yrs.	1	1
3 yrs.	1	1
3½ yrs.	2	
4 yrs.	3	
5 yrs.		1
5½ yrs.	1	
6½ yrs.	1	
13 yrs. (birth)		1
18 yrs.		1
none		1
	—	—
	33	12

Postoperative follow-up interval	Successes	Failures
1 mo.	2	
2 mos.		1
3 mos.		1
4 mos.	1	
6 mos.	1	
8 mos.		1
1–2 yrs.	6	2
2–3 yrs.	10	3
3–4 yrs.	4	3
4–5 yrs.	7	1
5–6 yrs.	2	
	—	—
Total	33	12
Not traced	2	
Grand total	47	

TABLE III.

Age	Successes	Failures
Oldest	62	62
Youngest	10	6
Average	28¼	32¼

Occupation	Successes	Failures
Student	13	1
Housewife	4	1
Laborer	4	2
Skilled laborer	5	1
Office worker	3	1
Nurse	2	1
School teacher	1	
Policeman		2
Priest		2
Infant		1
None	1	

Organic symptoms at time of operation	Successes	Failures
None	23*	2**
Aphasia	2	
Mental abnormality	1	4
Convulsions	5	4
Optic neuritis	1	1
Depressed fracture	1	
Hemiplegia		1

Type of accident	Successes	Failures
Automobile	12	3
Industrial	7	4
Fall	7	2
Athletic	4	
Blow	3	1
Birth injury		1
Unknown		1

*These patients represent 66.66 per cent of successes listed.
**Only 2 patients, or 16.6 per cent of failures, had no organic symptoms at the time of operation.

operation. Despite this obvious lack, however, my experience has satisfied me that this exploratory procedure is amply justified in any patient who is known to have sustained a craniocerebral injury, and who either asks to have it done or accepts it after having been told that it is quite as likely to be a useless as it is to be a useful procedure from his point of view.

CONCLUSIONS

1. In patients who complain of symptoms which persist for a month or more after their discharge from medical care following an acute craniocerebral injury, it should be possible, provided the patient is hospitalized, to make: (a) a probable diagnosis of head injury from the history; (b) an estimate of the efficiency of the earlier treatment and the probability of resultant late symptoms; and (c) a positive diagnosis of previously unknown intercurrent disease and of residual objective signs of the previous injury.

2. The resultant diagnoses should be phrased as follows: "No present evidence of organic disease"; "no present evidence of organic disease but a probable earlier craniocerebral injury"; or "present evidence of organic disease due to the residual effect of an old craniocerebral injury," or "to unconnected intercurrent disease."

3. These diagnoses should replace such meaningless and inaccurate terms as "posttraumatic and postconcussional neurosis" and should be made only after hospitalization of the patient.

4. They do not rule out the presence of such conditions as a subdural hematoma, cortical atrophy or scars, or psychotic maladjustments as the cause of the symptomatology.

5. Further investigative and diagnostic procedures include encephalography and transtemporal trephination.

6. In a group of 47 patients who subjected themselves to diagnostic transtemporal trephination for symptoms that persisted for 1 month to

18 years after craniocerebral injury, and who all had fluid cerebral subdural hematomas, it was found that (a) the patients who were successfully treated in this way averaged 4 years younger than the failures; (b) the shorter the interval between the injury and the drainage of the hematoma, the greater was the chance for cure; (c) only 33⅓ per cent of the successful cases in contradistinction to 83 per cent of the failures showed objective evidence of central nervous system disease in addition to the subjective symptoms, and (d) 73 per cent were permanently and completely relieved of objective and subjective symptomatology following removal of the fluid subdural hematoma.

REFERENCES

1. Coleman, C. C. Chronic subdural hematoma: diagnosis and treatment. Am. J. Surg., 1935, 28: 341.
2. LeFever, H. E., and Secrest, R. J. The late effects of cerebral trauma—a study of 100 old head injuries. Unpublished work.
3. Munro, D. The diagnosis, treatment and immediate prognosis of cerebral trauma. New England J. Med., 1934, 210: 287.
4. Idem. The diagnosis and treatment of subdural hematoma: Report of 62 cases. New England J. Med., 1934, 210: 1145.
5. Munro, D., and Merritt, H. H. The surgical pathology of subdural hematomas based on a study of 105 cases. Arch. Neurol. & Psychiat., 1936, 35: 64.
6. Von Storch, T. J. C., and Munro, D. Encephalography in the diagnosis of subdural hematomas. New England J. Med., 1938, 218: 6.

COMMITTEE ON ARRANGEMENTS

EXECUTIVE COMMITTEES

NEW YORK

Henry W. Cave, Chairman
Howard A. Patterson, Secretary
Frank E. Adair
Frederic W. Bancroft
Frank E. Berry
Robert E. Buckley
Ralph Colp
William Darrach
Carl Eggers
George J. Heuer
Charles Gordon Heyd
Robert H. Kennedy
Samuel J. Kopetzky
John A. McCreery
John J. Moorhead
Eugene H. Pool
James I. Russell
Morris K. Smith
J. Bentley Squier
Byron Stookey
George Gray Ward
Benjamin P. Watson
Carnes Weeks
*John M. Wheeler
Allen O. Whipple
Philip D. Wilson
Arthur M. Wright

*Deceased

BROOKLYN–LONG ISLAND

Donald E. McKenna, Chairman
Charles A. Anderson
Robert F. Barber
J. Wesley Bulmer
Chester L. Davidson
Augustus Harris
John E. Jennings
A. W. Martin Marino
Raymond B. Miles
Leo S. Schwartz
Fedor L. Senger
Robert A. Wilson

HOSPITAL REPRESENTATIVES

NEW YORK

Babies—Edward Donovan
Beekman Street—Sigmund Mage
Bellevue—Carnes Weeks
Beth Israel—Percy Klingenstein
Central Neurological—Thomas I. Price
Columbus—Carlo Savini
Flower-Fifth Avenue—Joseph H. Fobes
Fordham—E. R. Cunniffe
French—Harold B. Keyes
Gouverneur—Frank J. McGowan
Harlem Eye and Ear—Charles B. Meding
Harlem—Joseph B. Stenbuck
Margaret Hague Maternity (Jersey City, N.J.)—Samuel A. Cosgrove
Institute of Ophthalmology—John H. Dunnington
Hospital for Joint Diseases—Nicholas S. Ransohoff
Herman Knapp Memorial Eye—Arnold Knapp
Knickerbocker—John V. Bohrer
Lenox Hill—Carl Eggers
Lincoln—Edward Truesdell
Lutheran—Alfred G. Forman
Lying-In—Henricus J. Stander
Manhattan Eye, Ear and Throat—David H. Webster (Ophthalmology), Marvin F. Jones (Otolaryngology)
Memorial—Frank E. Adair
Metropolitan—Joseph H. Fobes
Misericordia—Joseph A. Devlin
Montefiore—Ira Cohen
Morrisania City—Clarence H. Smith
Mount Sinai—Sigmund Mage
Neurological Institute—Byron Stookey
New York City Cancer Institute—Ira I. Kaplan
New York City—Frederic W. Bancroft
New York Eye and Ear Infirmary—Francis W. Shine (Ophthalmology), Truman L. Saunders (Otolaryngology)
New York Foundling—George R. Stuart
New York—George J. Heuer
New York Infirmary for Women—Anna Hubert
New York Orthopaedic—Alan DeForest Smith
New York Polyclinic—Robert E. Brennan
New York Post-Graduate—Thomas H. Russell
Presbyterian—Allen O. Whipple
Riverside—Louis Carp
Roosevelt—William C. White
Hospital for Ruptured and Crippled—T. C. Thompson
St. Francis'—Robert B. Lobban
St. Luke's—Morris K. Smith
St. Vincent's—Raymond P. Sullivan
Seaview—Louis R. Davidson
Sloane—James A. Corscaden
Sydenham—Julius Jarcho
U. S. Marine (Stapleton)—William Y. Hollingsworth
Veteran's Administration—Allen G. Fuller
William Booth Memorial—Grant P. Pennoyer
Woman's—Albert H. Aldridge

BROOKLYN

Bay Ridge—Earl Mayne
Beth-El—Abraham Koplowitz
Beth Moses—Harry Feldman
Brooklyn Cancer Institute—John J. Gainey
Brooklyn Eye and Ear Hospital—E. Clifford Place (Ophthalmology), Robert Moorhead (Otorhinolaryngology)
Brooklyn—William Field
Caledonian Hospital—George Dixon
Carson C. Peck—Herbert T. Wikle
Coney Island—J. Earl Miles
Cumberland—Merrill Foote
Greenpoint—Peter Dulligan
Hospital of the Holy Family—Edwin H. Fiske
House of St. Giles—J. B. L'Episcopo
Jewish—Leo S. Schwartz
King's County—Joseph Tenopyr
Long Island College—Emil Goetsch
Lutheran—A. V. Fardelmann
Methodist Episcopal—Henry Graham
Midwood—Walter Coakley
Norwegian—Henry Fisher
Prospect Heights—Howard Blair
St. Catherine's—William C. Meagher
St. John's—Stanley Thomas
St. Mary's—Thomas M. Brennan
St. Peter's—J. L. McGoldrick
Trinity—Irving Tran
U. S. Naval—Commander Savage
Wyckoff Heights—John L. Bauer

QUEEN'S COUNTY

Flushing—William K. Rogers
Jamaica—L. Howard Moss
Mary Immaculate—John Scannell
Queen's General—Joseph Thomas
Rockaway Beach—Chester L. Davidson
St. John's—William Lavelle

NASSAU AND SUFFOLK COUNTIES

Brunswick General—Charles C. Murphy
Huntington—Roger Dexter
John T. Mather—Frank S. Child
Meadowbrook—A. Storrs Warinner
Nassau—Benjamin Seaman
North Country Community—J. Wesley Bulmer
Southampton—David H. Hallock
Southside Hospital—E. R. Hildreth

CLINICAL CONGRESS TECHNICAL EXHIBITION

LEADING manufacturers of and dealers in surgical instruments, hospital apparatus and supplies, diagnostic and therapeutic apparatus, pharmaceuticals, and publishers of medical and surgical books were represented in the Technical Exhibition at the Waldorf-Astoria Hotel in New York, October 17–21, 1938.

A. S. Aloe Co., St. Louis
American Congress of Obstetrics and Gynecology, Chicago
American Cystoscope Makers, Inc., New York
American Hospital Supply Corp., Chicago
American Journal of Surgery, New York
American Safety Razor Corp., Brooklyn
American Sterilizer Co., Erie, Pa.
D. Appleton-Century Co., New York
Armour & Co., Chicago
Austenal Laboratories, New York
C. R. Bard, Inc., New York
Bard-Parker Co., Danbury, Conn.
W. A. Baum Co., Inc., New York
Baxter Laboratories, Glenview, Ill.
Rudolph Beaver, Inc., Waltham, Mass.
Becton, Dickinson & Co., Rutherford, N. J.
Julius Berbecker & Sons, New York
Burdick Corp., Milton, Wis.
S. H. Camp & Co., Jackson, Mich.
Wilmot Castle Co., Rochester, N. Y.
Warren E. Collins, Inc., Boston
Crane Co., Chicago
Crescent Surgical Sales Co., New York
R. B. Davis Sales Co., Hoboken, N. J.
Davis & Geck, Inc., Brooklyn
J. A. Deknatel & Son, Queens Village, N. Y.
DePuy Manufacturing Co., Warsaw, Ind.
Duke Laboratories, Long Island City, N. Y.
E. & J. Co. of New York, New York
Eastman Kodak Co., Rochester, N. Y.
Foregger Co., New York
General Electric X-Ray Corp., Chicago
Gudebrod Bros. Silk Co., Philadelphia
Fred Haslam & Co., Brooklyn
Paul B. Hoeber, Inc., New York
Huntington Laboratories, Huntington, Ind.
Johnson & Johnson, New Brunswick, N. J.
Jones Metabolism Equipment Co., Chicago
Kny-Scheerer Corp., Long Island City, N. Y.
Lea & Febiger, Philadelphia
Lederle Laboratories, New York
Lewis Manufacturing Co., Walpole, Mass.
Liebel-Flarsheim Co., Cincinnati, O.
The Linde Air Products Co., New York
J. B. Lippincott Co., Philadelphia
MacGregor Instrument Co., Needham, Mass.
Macmillan Co., New York
E. F. Mahady Co., Boston
McKesson Appliance Co., Toledo, O.
Medical Bureau, Chicago
Merck & Co., Rahway, N. J.
E. B. Meyrowitz Surgical Instruments Co., New York
Modern Surgical Instrument Co., New York
C. V. Mosby Co., St. Louis
V. Mueller & Co., Chicago
New York Medical Exchange, New York
Ohio Chemical & Manufacturing Co., Cleveland
Petrolagar Laboratories, Chicago
Physicians' Record Co., Chicago
George P. Pilling & Son Co., Philadelphia
Prometheus Electric Corp., New York
Radium Chemical Co., Inc., New York
Radium Emanation Corp., New York
Sanborn Co., Cambridge, Mass.
W. B. Saunders Co., Philadelphia
Scanlan-Morris Co., Madison, Wis.
J. Sklar Manufacturing Co., Brooklyn
C. M. Sorensen Co., Long Island City, N. Y.
E. R. Squibb & Sons, New York
Sterisol Ampoule Corp., Brooklyn
Taylor Instrument Cos., Rochester, N. Y.
Charles C. Thomas, Springfield, Ill.
Tower Co., Seattle
Union Carbide Company, New York
Wallace & Tiernan Products, Inc., Belleville, N. J.
Wilson Rubber Co., Canton, O.
Winthrop Chemical Co., New York
Max Wocher & Son Co., Cincinnati, O.
William Wood & Co., Baltimore
Zimmer Manufacturing Co., Warsaw, Ind.